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A Summary of Current Program and  
Preliminary Report of Progress

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U. S. DEPT. OF AGRICULTURE  
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POTATO RESEARCH

of the

FEB 4 - 1965

United States Department of Agriculture  
and Cooperating Agencies

CURRENT SERIAL RECORDS

This progress report of U.S.D.A. and cooperative research is primarily a tool for use of scientists and administrators in program coordination, development, and evaluation; and for use of advisory committees in program review and development of recommendations for future research programs.

The summaries of progress on U.S.D.A. and cooperative research include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to members of Department staff, advisory committee members and others having an interest in the development of public agricultural research programs.

This report also includes a list of publications reporting results of U.S.D.A. and cooperative research issued during the last year. Current agricultural research findings are also published in the monthly U.S.D.A. publications, Agricultural Research, Agricultural Marketing, and The Farm Index.

UNITED STATES DEPARTMENT OF AGRICULTURE

Washington, D. C.  
December 31, 1964



## ADVISORY COMMITTEES

The research program of the Department of Agriculture is reviewed annually by the following advisory committees:

1. Farm Resources and Facilities Research
2. Utilization Research and Development
3. Human Nutrition and Consumer Use Research
4. Marketing Research
5. Agricultural Economics Research
6. Forestry Research
7. Animal and Animal Products Research
8. Cotton Research
9. Grain and Forage Crops Research
10. Horticultural Crops Research
11. Oilseed, Peanut and Sugar Crops Research
12. Plant Science and Entomology Research
13. Tobacco Research

## ORGANIZATIONAL UNIT PROGRESS REPORTS

The source materials used by the advisory committees are of two types. First there are Organizational Unit Reports that cover the work of the Divisions or Services listed below. The number prefixes refer to advisory committees listed above that review all of the work of the respective Divisions or Services.

### Agricultural Research Service (ARS)

- 1 - Agricultural Engineering
- 1 - Soil and Water Conservation
- 2 - Utilization -- Eastern
- 2 - Utilization -- Northern
- 2 - Utilization -- Southern
- 2 - Utilization -- Western
- 3 - Human Nutrition
- 3 - Clothing and Housing
- 3 - Consumer and Food Economics
- 4 - Market Quality
- 4 - Transportation and Facilities
- 7 - Animal Husbandry
- 7 - Animal Disease and Parasite
- 12 - Crops
- 12 - Entomology

### Economic Research Service (ERS)

- 1, 5 - resource Development Economics
- 4, 5 - Marketing Economics
- 5 - Farm Production Economics
- 5 - Economic and Statistical Analysis
- 5 - Foreign Development and Trade Analysis
- 5 - Foreign Analysis Division

### Forest Service - Research (FS)

- 6 - Forest Economics and Marketing
- 6 - Forest Products and Engineering
- 6 - Forest Protection
- 6 - Timber Management
- 6 - Watershed, Recreation and Range

### Other Services

- 4, 5 - Farmer Cooperative Service (FCS)
- 4, 5 - Statistical Reporting Service(SRS)

## SUBJECT MATTER PROGRESS REPORTS

The second type of report brings together the USDA program and progress for the following commodities and subjects:

- |                                          |                                      |
|------------------------------------------|--------------------------------------|
| 3 - Rural Dwellings                      | 8 - Cotton and Cottonseed            |
| 6 - Forestry (Other than Forest Service) | 9 - Grain and Forage Crops           |
| 7 - Beef Cattle                          | 10 - Citrus and Subtropical Fruit    |
| 7 - Dairy                                | 10 - Deciduous Fruit and Tree Nut    |
| 7 - Poultry                              | 10 - Potato                          |
| 7 - Sheep and Wool                       | 10 - Vegetable                       |
| 7 - Swine                                | 10 - Florist, Nursery and Shade Tree |
| 7 - Cross Species and Miscellaneous      | 11 - Oilseeds and Peanut             |
| Animal Research                          | 11 - Sugar                           |
|                                          | 13 - Tobacco                         |

A copy of any of the reports may be requested from Barnard Joy, Research Program Development and Evaluation Staff, U. S. Department of Agriculture, Washington, D. C. 20250.

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## INTRODUCTION

This report deals with research on the white or Irish potato (not sweet-potato) and covers work directly related to the production, processing, distribution and consumption of potatoes and potato products. It does not include extensive cross-commodity work, much of it basic in character, which contributes to the solution of problems of other commodities as well as those of potatoes. The progress on cross-commodity work is found in the organizational unit reports of the several research divisions of the Department.

This report is organized by problem areas which are shown as the major subjects under the three main divisions in the table of contents. For each of the problem areas there is a statement of (1) Problem, (2) USDA AND COOPERATIVE PROGRAM, (3) PROGRAM OF STATE EXPERIMENT STATIONS, (4) PROGRESS--USDA AND COOPERATIVE PROGRAMS, (5) PUBLICATIONS--USDA AND COOPERATIVE PROGRAMS.

Research on potato problems is supported by (1) Federal funds appropriated to the research agencies of the USDA, (2) Federal and State funds appropriated to the research agencies of the USDA, and (3) private funds for research carried on in private laboratories or for support of State Station or USDA work.

### Research by U.S.D.A.

#### Farm Research

Farm Research comprises investigations on introduction, breeding and genetics, variety evaluation, culture, diseases, nematodes, weed control, insects, and crop harvesting and handling operations and equipment. This research is conducted by the Crops, Entomology and Agricultural Engineering Divisions of the Agricultural Research Service; and in fiscal year 1963 involved 23 professional man-years.

#### Nutrition, Consumer and Industrial Use Research

Nutrition and consumer-use research pertains to composition and nutritive value; physiological availability of nutrients and their effects; and new and improved methods of preparation, preservation and care in homes, eating establishments and institutions. This work is done by the Divisions of Human Nutrition Research and Consumer and Food Economics Research of the Agricultural Research Service .

Utilization research deals with methods of preservation of potatoes through canning, drying, freezing, or combinations of these methods and also with the origination of new forms of food products or combinations of potatoes with other foods. It is also concerned with improved equipment and processes. The work is done by the Eastern

Utilization Research and Development Division, Wyndmoor, Pennsylvania; by the Western Utilization Research and Development Division at Albany, California; under contracts with foreign country laboratories; and in cooperation with the industry and other organizations mentioned under Program for each research area.

### Marketing and Economic Research

Marketing research involves the physical and biological aspects of assembly, packaging, transporting, storing and distribution from the time the product leaves the farm until it reaches the ultimate consumer. The work reported herein is conducted by the Market Quality and Transportation and Facilities Research Divisions of the Agricultural Research Service. Economic research is concerned with market potentials for new products and uses; merchandising and promotion, economics of transportation and storage, marketing costs, margins and efficiency; market structure, practices and competition; information, outlook and rural development; supply, demand and price; situation and outlook; and improving marketing through research with farmer cooperatives. The work reported herein is done by the Economic and Statistical Analysis and the Marketing Economics Research Divisions of the Economic Research Service; by the Standards and Research Division of the Statistical Reporting Service; and by the Marketing Division of the Farmer Cooperative Service.

### Interrelationships Among Department, State and Private Research

Much of the Department's research is cooperative with State Experiment Stations, various sectors of industry and with growers. Cooperative work is jointly planned and frequently participated in by Federal, State and industry workers. The nature of the cooperation varies with each study. It is developed to fully utilize the personnel and other resources of the cooperators. There is regular exchange of information between State and Department scientists to assure that the research programs complement each other and eliminate undesirable duplication. Many Department employees are located at State Stations and use laboratories and office space close to, or furnished by the State.

Privately supported research of considerable extent is done by food processors and distributors, chemical and fertilizer companies, manufacturers of materials handling systems, food industry and trade associations, food container and equipment suppliers, package and container manufacturers, market research institutes and corporations, seed suppliers and growers. Industry's cooperation in supporting research on potatoes in the form of grants, gifts or loans of materials, equipment and facilities at Federal and State stations has contributed greatly to its success.

A number of food processing companies and wholesale and retail distributors are presently conducting research in various phases of products and process development in frozen, canned, and dried potato products. The canning, freezing and dehydrating industries each maintain an association with a technical staff and either do research in their own laboratories or support research at U.S.D.A. laboratories, universities and other organizations. Allied industries and suppliers to the food processing industry maintain excellent laboratories and large research staffs to provide technical information to the industry.

Marketing equipment and facility manufacturers also make sizeable contributions to research on the development of equipment for handling potatoes on the farm, into and out of packing houses, transportation vehicle, wholesale distribution center and in the retail establishment as well as research on the containers in which they are moved and on the transportation vehicles from which they move from one point in the distribution channel to another. Market research institutes and others in marketing economics research are largely concerned with research in consumer preference, market potentials, and interregional and intermarket competition.

Chemical and fertilizer companies are significant factors in research on the development of new materials or combinations of materials to produce more efficiently, high quality potatoes through better nutrition of the growing plant, control of diseases, insects, nematodes, weeds, killing of tops, skin color intensification and protective waxes.

Several of the seed certification associations as well as large private seed producers expend considerable time and money on varietal adaptation experiments and disease tolerance readings that are so necessary to determine the acceptability of standard varieties and the new varieties that appear at frequent intervals from the potato breeders; Federal, State and private. The contribution of growers to our overall research effort on potatoes is substantial. Certainly, in the field of production his help is indispensable for most of the laboratory research results must finally be confirmed by field experiments. The grower cooperates with the U.S.D.A., State Experiment Stations and suppliers of many materials and equipment; usually without compensation except for the experience and knowledge gained.

#### Examples of Recent Research Accomplishment by USDA and Cooperating Scientists

Discoloration of Potatoes. The tendency for the cut surfaces of potatoes to turn dark when exposed to air often lowers the quality of processed potato products, particularly prepeeled potatoes. Although darkening can be retarded by treating the tissue with sulfites, this may introduce an off-flavor that is objectionable to some people. Public Law 480-supported studies have shed new light on the phenomenon of darkening and suggest a new approach to solution of the problem. It was found that the major factor determining the rate



of discoloration is the concentration of the compound, tyrosine, in the tuber and that the tyrosine level is largely influenced by the amount of water available to the growing plant and to a lesser extent by certain other cultural factors. Modification of irrigation schedules and other farming practices may yield potatoes much less susceptible to darkening. This will make possible the development of a consumer retail market for prepeeled potatoes which until now have only been sold to institutional users because of their relatively short storage life.

Promotional Expenditures by Producer Organizations. -- A survey of promotional expenditures of producer organizations and similar agriculturally oriented groups indicates that there are almost 1,200 of these organizations spending a total of about \$86 million annually for the promotion of agricultural products. This is an increase of nearly \$20 million over expenditures shown by these organizations in a similar survey in 1958. This increase in expenditures represents added self-help efforts by producer groups to build and strengthen markets for their products and to combat the problem of an imbalance between demand and supply. Fruit, which was the leading product promoted, and dairy, which ranked second, accounted for well over 50 percent of these expenditures. Meat and livestock products ranked third with expenditures of over \$6 million per year. Promotional expenditures for natural fibers, poultry and eggs, and field crops were comparable ranging between \$4 and \$5 million per year for each commodity class.

Voluntary producer-processor groups spent more than any of the other groups, with expenditures of nearly \$32 million per year. Cooperatives and commissions and boards operating under enabling legislation were also important, with each type of organization spending about \$25 million per year. State Departments of Agriculture and other organizations not identified spent less than the other types of organizations, with expenditures in each of these categories averaging about \$1.5 million per year.

Philadelphia Food-Distribution Center Nearing Completion. In Philadelphia, as a result of studies of the facilities used for handling food, construction is almost complete on the 388-acre food-distribution center. When completed, the development will represent an investment of over \$100 million and provide employment for about 12,000 people in handling and processing all types of food and food products and related service industries. Prior to the development of the center, the tax income from the site was \$29,000 per year and when construction is completed, will be almost \$2.0 million annually. The old market has been replaced with three apartment buildings and a number of townhouses, increasing the assessed valuation from about \$7.0 to \$27.0 million.

Development of Design for Multi-Purpose Van Container. A design for a multi-purpose van container for transporting farm and food products has been developed. When completed, the van can haul frozen and nonfrozen products as well as dry cargo. It can be moved by highway, rail, water, and possibly air. When widely adopted, and industry interest indicates it will be, the van container will bring significant reduction in the annual bill for transporting agricultural products and supplies, and at the same time furnish better protection to products which require special environment during transit.



## I. FARM RESEARCH

POTATO CULTURE, BREEDING, DISEASES, AND VARIETY EVALUATION  
Crops Research Division, ARS

Problem. Potatoes are grown in all 50 States and are planted and harvested every month of the year, increasing the demand for varieties for regional adaptation and specialized uses and markets. New cultural practices necessitated by economic pressures for greater efficiency in production have tended to lower potato quality. Expanding research to reverse this trend is desirable. The increase in potato processing (from 3.2 million hundredweight processed in 1940 to 63.7 million in 1962) has created a demand for new, more suitable varieties. The development of the food processing industry is one of the most dynamic of any phase of agriculture today. At least 50 products of various kinds are processed from potatoes. Basic information on genetic control of enzyme systems for developing potato varieties more suitable for processing is needed. Potentially valuable Solanum species and released varieties are not presently fully evaluated. To raise yields and potato quality beyond present levels requires new methods of breeding, more interspecific hybridization, and greater resistance to specific diseases. Potato diseases annually continue to cause significant losses at all levels of the industry. Information is needed on the nature of diseases and new methods of their control. Increasingly serious are stem-end browning, after-cooking darkening, and internal black spot. Causes and cures for these disorders are urgent. Genetic controls for insects and nematodes are needed to supplement and if possible replace chemical control.

## USDA AND COOPERATIVE PROGRAM

Breeding, selecting, and testing of new varieties and seedlings for horticultural characters, storing, shipping, and culinary qualities, and local adaptation are conducted cooperatively with the States at Presque Isle, Maine; Greeley, Colorado; Aberdeen, Idaho; Ames, Iowa; Baton Rouge, Louisiana; Ithaca, New York; Prosser, Washington; and Crystal City, Texas. In addition, testing of new seedlings is done at more than 25 additional locations in cooperation with State personnel.

Greenhouse crossing for production of true seed, for developing new varieties, and growing seedling tubers is done at Beltsville, Md., and to a lesser degree at Aberdeen, Baton Rouge, Prosser, and Greeley. Frost resistance is being developed in selections at Baton Rouge for winter crop production. At Aberdeen, Beltsville, Greeley, and Presque Isle emphasis is placed on developing varieties adapted for processing. The development of insect-resistant lines is a major objective. In cooperation with the Rockefeller Institute at Mexico City, seedlings from Beltsville are evaluated for field resistance to severe late blight conditions of the Toluca Valley; significantly resistant varieties have been released.

Lines resistant to wind and heat are being developed in Texas with assistance of private cooperators. Parental lines and advance seedling selections that have resistance to sloughing off and that retain their opaqueness when diced, frozen, and reconstituted are being sought, also, through private cooperation, in Georgia, Maine, Maryland, New Jersey, Ohio, Pennsylvania, Texas, and Wisconsin.

The world collection of Solanum stocks is maintained at Sturgeon Bay, Wisconsin, at the Inter-Regional Potato Introduction Station. The production and study of Solanum tuberosum diploids (half the normal chromosome number) is done at Madison, Wisconsin along with interspecific hybridization of diploids. At Beltsville investigations of crossability among Solanum species and meiosis of species and species hybrids are being conducted.

Disease controls are sought through breeding disease-resistant varieties and basic studies on the nature of specific diseases.

Scab resistance is a major breeding objective at all locations. The evaluation of progenies, seedling selections, and species for viruses X, A, and Y is done at Beltsville. Through State cooperators seedlings from Beltsville are sent to Florida for determining corky-ring-spot resistance, to New York for resistance to golden nematode, and to Ohio for insect-resistant characteristics. At Beltsville work is done on the development of techniques for evaluation tests of all major diseases with particular stress on leafroll and the viruses. Studies are underway to find improved methods of disease detection.

At Greeley, Colo., lines are developed that are resistant to scab and leafroll, and at Aberdeen, Idaho and Prosser, Wash., to scab, leafroll, and verticillium wilt. Early blight and fusarium resistance tests are conducted at Aberdeen. At Baton Rouge, La., emphasis is placed on scab and late blight resistance, especially in red-skinned lines. At Presque Isle, Maine, disease evaluations are made for X, A, Y, leafroll, spindle tuber, ring rot, verticillium wilt, late and early blight, scab, and tuber necrosis. Disease control studies for late blight, scab, verticillium wilt and viruses are likewise conducted in Maine. Internal black spot is a major consideration at our New York and Washington locations. Evaluation of breeding lines for resistance to golden nematode is done cooperatively at Ithaca, N. Y. Virus S is studied at Greeley.

Epidemiological research was continued on late blight of potatoes at the State Experiment Stations of Iowa and Pennsylvania.

Virus indexing of new potato introductions was done at the National Plant Introduction Station at Glenn Dale, Maryland.

Thirteen Federal professional man-years annually are devoted to this work. Of this total 7.7 is devoted to breeding; 4.2 to diseases; 0.1 to variety evaluation; 1.4 to culture.



Two 5-year PL 480 projects are currently in effect: (1) with the Polish Academy of Science, Krakow, Poland, for study of environmental factors affecting quality of tubers used for seed (E21-CR-24) providing funds with a \$48,548.83 equivalent in Polish zlotys, and having a projected duration from 1962 to 1967; (2) with the Estacion de Mejora de la Patata,

Vitoria, Spain, to develop techniques for eradicating, inactivating, or curing potato tubers from their tuber-borne viruses (E25-CR-14) providing funds with a \$45,959 equivalent in Spanish pesetas, and having a projected duration from 1963 to 1968.

#### PROGRAM OF STATE EXPERIMENT STATIONS

A number of State stations are undertaking cultural research with potatoes aimed at increasing efficiency of production under local conditions. This research includes mineral nutritional studies of source and rates of fertilization, minor element nutrition, fertilizer requirements under different soil and climatic conditions, methods of application, and irrigation studies. Chemical and other methods of killing vines are being investigated. Results are expressed in terms of yield, grade, specific gravity, storage quality, susceptibility to bruising, and processed quality.

Potato breeding at the State stations is closely cooperative with the National Potato Breeding Program of the Department. Breeding and variety evaluation projects are designed to produce varieties adapted to a given State or area. Selection criteria include yield; grade; quality of the processed product and cooking quality; shape; color; storage ability; earliness; resistance to heat, drought, and frost; and resistance to diseases such as the virus diseases of potato, ring rot, late blight, and scab.

The breeding program is strengthened by fundamental research in genetics and cytogenetics. The IR-1 (Interregional) project, Introduction, Preservation, Classification, Distribution, and Preliminary Evaluation of Wild and Cultivated Species of Solanum, is an invaluable aid to potato research.

Diseases of potato represent a costly, and in many cases a limiting factor, in potato production. There are not only the direct costs of crop failure due to disease, but the indirect costs of chemical control, limits on land use in an effort to control disease, and limits on plant materials to obtain resistance. There is an extensive program of research at the State stations designed to solve the disease problems. A portion of this effort is devoted to applied and developmental phases, such as forecasting and detection work on late blight, nematodes, verticillium wilt, and certain viruses. More efficient crop sequence systems and the role of crop residues in disease control is being investigated. A wide range of basic studies on diseases of potato include work on viruses, fungi, nematodes, and bacteria. Leadership in nematode research is aided by three regional research projects on phytonematology.

Research on virus diseases includes genetic resistance to the spindle tuber virus. Other viruses such as leafroll, X, Y, and numerous strains are receiving special attention.

Resistance to verticillium wilt, late blight, scab, fusarium root rot, powdery scab and Rhizoctonia blight and bacterial diseases, such as ring rot, are receiving specialized attention in some studies through a number of well coordinated research efforts.

The total research effort on potatoes at the State stations is approximately 39.7 professional man-years, of which 6.4 is for culture, 23.7 for breeding and variety evaluation, and 9.6 for disease investigations.

## PROGRESS -- USDA AND COOPERATIVE PROGRAMS

### A. Breeding

1. Potato Tuber-greening. Segregation into greening classes of 1,378 single-tuber seedlings from 17 family lines and their parents were measured objectively for intensity of greening, using a light transmittance instrument with special attachments to correct variation between samples. Differences in segregation were found between families.

Greening classes for 473 varieties and advance selections were also determined. Of the varieties exposed, Antigo, Blanca, and Norland showed the most resistance to tuber-greening. Seedlings B4828-4, B4829-7, B5000-18, B5052-17, and B5063-3 were a few of the better advance selections with resistance to greening.

2. Spindle Tuber. In cooperation with the Maine Agricultural Experiment Station, out of 400 seedlings evaluated, nine have shown a high level of resistance after two inoculations. Survivors from former tests were re-inoculated and indexed. Results of these tests show varying levels of resistance to mechanical inoculation in the field, but not immunity. This is the first evidence of the existence of resistance to spindle tuber virus in the cultivated potato.

3. Potato Cytogenetics. In cooperation with Wisconsin Agricultural Experiment Station, emphasis was given to employing haploids in genetics, cytogenetics, and breeding studies. Over 1,000 haploids of S. tuberosum were grown in 2- or 4-hill rows for evaluating fertility, productivity, and general variability. A total of 365 haploid clones flowered and were used in crosses with other haploids, diploid species, or F<sub>1</sub> clones of diploid species-haploid crosses. Eighty-eight haploids were used successfully as female parents. Fertility studies of 102 haploids from Germany showed that 84 percent of the 67 clones that flowered set seed after pollination with haploids or diploids and 53 percent were rated as male fertile when pollen was germinated on artificial medium. The potato-tomato graft technique, followed with a colchicine treatment, was used on 1 to 4 plants of 61 diploid clones to induce doubling of their chromosome number. This method was very effective, and 36 haploid clones were doubled for further studies.

Several clones of 49 diploid species and 75 diploid interspecific hybrid progenies were grown for cytological and crossability studies at Beltsville. F<sub>1</sub>, F<sub>2</sub>, and backcross seed was obtained, as well as 25 combinations of interspecific crosses between tetraploid and diploid species. Male-sterility in one diploid interspecific progeny indicated a cytoplasmic condition. Meiosis was normal in most species and interspecific hybrids.

4. Late Blight. Over 200 seedling selections were tested for field resistance to late blight at Toluca, Mexico, in cooperation with the Rockefeller Foundation. Several seedlings showed high field resistance and will be used as future parents. One of these is B5281-1 which yielded over 300 hundredweight per acre in Maine, and has resistance to scab and virus X.

5. Verticillium wilt. In cooperation with the Maine Agricultural Experiment Station, approximately 8 seedlings out of 250 showed no wilt symptoms in the field.

6. Leafroll. In cooperation with the Maine Experiment Station, 6 parents and 36 selections out of 310 showed high field resistance to leafroll. Seedlings B5006-6 and B5063-3 are examples of high yielding seedlings that have leafroll resistance combined with other disease-resistant characters.

7. Net Necrosis and Stem-end Browning. Forty varieties and seedlings were field-tested for tuber necrosis symptoms due to seasonal infection with leafroll (net necrosis) and physiological necrosis (stem-end browning). The tubers of Green Mountain and Mohawk showed approximately 39 and 27 percent net necrosis, respectively, but they had no stem-end browning symptoms. Twenty seedlings were found free of any tuber type discoloration and only 14 seedlings out of 36 tested expressed symptoms in their tubers. This resistant characteristic is very valuable in table and processing potatoes.

8. Golden Nematode. In cooperation with the New York Agricultural Experiment Station, 70 seedlings out of 132 were found resistant. Several advance selections from these tests are being increased for commercial consideration, including B4473-3, B4528-3, and B4557-2.

9. Scab. In 1963, out of a total of 251 selections tested for scab resistance, 22 were found to be free of scab. Seedling B5236-8 with only a trace of scab will be increased since it also has resistance to viruses X and Y, good tuber shape and yielding ability.

10. Ring Rot. In cooperation with the Maine Agricultural Experiment Station, 10 selections out of 283 screened for ring rot resistance showed no evidence of the disease. Two seedling sibs, B3478-23 and B3478-22, when grown in a replicated yield trial, produced 360 and 341 hundredweight per acre, compared to 324 hundredweight for Katahdin.



11. Southern Region. In cooperation with the Louisiana Agricultural Experiment Station, 5 seedlings with late blight and scab resistance yielded more per acre than LaSoda, and have commercial possibilities. Specific gravity for seedlings TL7627 and TL8131 was 1.087 and 1.084, compared to 1.071 for LaSoda. Three out of 28 clones tested for frost resistance were rated as highly resistant. Selection 22-241, highly resistant to frost, had a specific gravity rating of 1.073, was fertile, and produced seed in the field.
12. Colorado. In cooperation with the Agricultural Experiment Station of Colorado and Wyoming, 16 of over 150 selections field-tested for resistance to verticillium wilt and early blight were rated as having no wilt symptoms and having only 0 to 6 percent of their vines infected with early blight. One of these, B5052-7, was reported as highly resistant to early blight and leaf hopper injury in Ohio.
13. Idaho. In cooperation with the Idaho Agricultural Experiment Station, of 16,000 single-hill seedlings grown in the field, 160 were selected for future study and evaluation. Seedlings A598-3, A483-17, and A610-9 are long, russet-types that outyielded the standard Russet Burbank variety significantly and were also superior in resistance to verticillium wilt and scab. Fourteen of 25 seedlings tested for wilt resistance in the Egin Bench area had significantly lower wilt indices than Russet Burbank.
14. Washington. In cooperation with the Washington Agricultural Experiment Station, about 35,000 single-hill seedlings were grown in the field and 61 russet-skinned selections were saved for future study. Selections 48-1, B3620-1, B5023-42, and B5063-3 were increased under contract in Washington for commercial testing. Thirty-one advance selections from 187 sent from Maine showed no wilt symptoms in Washington. Thirty-two varieties and selections grown at Othello were compared for yield, specific gravity, black spot discoloration, hollow heart, and chip color. The highest yielding seedling, A576-2, with 832 hundredweight per acre graded out only 399 sacks of U.S. No. 1 tubers compared to 630 hundredweight for Kennebec with 491 sacks of U.S. No. 1 tubers. Significant differences for resistance to internal black spot were observed between varieties and/or between selections.
15. Texas. In cooperation with the Texas Agricultural Experiment Station, 31 selections out of 82 were rated as worthy of increase and inclusion in the 1964 yield tests. Eighteen varieties and seedlings were compared for yielding ability and specific gravity on four harvest dates. In general yields continued to increase as the length of growing season was extended. Specific gravity did not vary appreciably with length of growing season. Several seedlings, BX4825-3, BT4992-3, and BT4994-2, yielded over 200 hundredweight per acre when grown at Crystal City, and compared favorably with Redskin, Ona, Kennebec, and Red LaSoda.

## B. Diseases

1. Spindle Tuber Virus. In a comparative study with the tomato bunchy-top virus from South Africa, carried out under quarantine conditions, potato spindle tuber virus appeared to be almost identical in symptoms produced on tomato and potato. Host ranges of the two viruses also appear to be identical. These data indicate that potato spindle tuber and tomato bunchy-top are probably caused by the same virus and the information available on tomato bunchy-top may be applied to the spindle tuber problem.

Major emphasis is now being placed on purification and determination of the biological properties of the spindle tuber virus. The finding of an indicator plant for this virus at this laboratory has stimulated work at several institutions here and abroad.

2. Evaluation of Solanum Species. About 200 clones of 42 Solanum species were retested for resistance to viruses X, Y, and leafroll--the latter in cooperation with the Maine Agricultural Experiment Station. No clones were resistant to virus Y in this year's test, but two clones of S. acaule that were resistant to leafroll in 1962 were also resistant in 1963.

3. Evaluation of Breeding Selections. Approximately 400 advanced breeding selections were tested for resistance to viruses A, Y, X, and late blight. About 116 selections remained free of blight throughout the season due to late development of new races in the field. Over 140 selections carried major genes for resistance to blight; 101 contained single genes, predominantly the  $R_1$ ; 33 selections had two major genes; 10 selections had three major genes. Only 13 selections of 420 tested were resistant to aphid inoculation with virus Y in 1963. About half or 214 selections were resistant to sap inoculation with virus X, but only 74 of these were resistant to graft inoculation. Almost  $3/4$ , or 302 of the 420 selections tested for resistance to aphid inoculation with virus A, were resistant, but only 111 of these were resistant to graft inoculation with the virus.

4. Control of Spread of Virus A. In cooperation with the Entomology Research Division a test with oil sprays for control of virus Y was initiated. A plot cooperative with the Oregon Agricultural Experiment Station, using virus A, was also initiated. Results were sufficiently encouraging to merit a further test in 1964.

5. Late blight of potato and tomato. Inoculated and noninoculated Cobbler and Norland seed pieces were planted in "late blight gardens" at Clear Lake, Ames, and Boone, Iowa. Records of weather and late blight occurrence were made for the period from sprout emergence to maturity. No late blight appeared in any of the plots. High soil temperatures, ranging from 83° to 92° F at the 1-inch depth as recorded at Ames for 4 days preceding emergence, may have killed the pathogen in the young sprouts. Foliage inoculations were made during the second week of July. No symptoms of late blight were observed in the Clear Lake garden.

Observations on time of deposition and duration of dew were made in the Ames garden during June and July. Dew was present on potato leaves on 8 nights in June and 28 nights in July. Both months are usually considered dewless. Generally, dew appeared between 7:00 and 9:00 p.m. "Burn-off" occurred mostly between 6:00 and 8:00 a.m. Relative humidity readings at the time of visual dew appearance showed that on 15 of 23 nights relative humidity was 100 percent in the crop while the highest reading in the instrument shelter for the 23 nights was 98 percent. Data on weather, crop development, and late blight occurrence for a 16-week period were recorded in 23 locations in the 8-state north central region and interpreted at the regional office in terms of late blight severity values. Based on these data the one location for which late blight forecasts were not accurate was the Moorhead, Minnesota area. Here the phytoclimatic records were not begun until 6 weeks after emergence.

In the northeastern region four late blight stations were established in Pennsylvania in 1963 to evaluate forecast criteria used in two methods: one based on moving rainfall-temperature graphs, the other on late blight severity values. Both methods were accurate in that late blight was absent in the vicinity of the stations when criteria for a positive forecast were not met or only minimally met. However, the presence of cull piles may make modification of the criteria desirable.

6. Virus Indexing of Introductions. During 1963, about 100 new potato introductions were indexed at Glenn Dale for virus diseases, of which half were detained for further study. Only 20 introductions were released as virus-free while 24 contained viruses already present in the U. S. This latter group will be grown under quarantine at the Sturgeon Bay Introduction Station for true seed production. Five new potato varieties released in 1961 and 1962 by U. S. breeders contained from 3 to 6 foreign introductions in their pedigree.

### C. Variety Evaluation

1. New Releases. Penobscot was released cooperatively with the Maine Agricultural Experiment Station. The small amount of available certified seed is the limiting factor for commercial production of this leafroll-resistant variety. Shoshoni was released cooperatively with the Idaho Agricultural Experiment Station as a round, russet variety with good processing characteristics for dehydrated products, and resistance to scab and verticillium wilt. Tests this year indicate that Shoshoni also has the R<sub>1</sub> factor for late blight resistance and is immune from virus X.



2. Outstanding Seedlings. B4828-4 is a high-yielding red selection with resistance to tuber-greening, scab, silver scurf, corky ringspot, ring rot, virus A, and sloughing and translucency after freezing and thawing of dices. B5052-7, a medium-yielding white selection with excellent oblong tubers, is resistant to early blight, late blight, scab, verticillium wilt, hopperburn, and virus X. It is adapted for use in canning and frozen soups due to resistance to sloughing and translucency. B5052-14, a high-yielding white selection, is similar to its sib, B5052-7, for processing qualities and is resistant to late blight, scab, verticillium wilt, virus X, and silver scurf. B4846-14, a late-maturing yellow-flesh selection, has a relatively high solids content and is resistant to tuber-greening, late blight, scab, viruses X and A, corky ringspot, and golden nematode. The above selections have all produced over 300 hundredweight of U.S. No. 1 tubers per acre in 1962 and 1963.

3. Potato Introductions. In cooperation with Plant Introduction Investigations of the New Crops Research Branch, 57 new stocks were received in 1963 from 10 countries (Australia, Bolivia, Canada, Chile, Germany, Italy, Japan, Mexico, Peru, and Russia). Approximately 200 seed and 300 tuber collections were made in 1963 by the National Science Foundation-sponsored Solanum expedition to Mexico and South America. These stocks will be included in the IR-1 collection. Seed of 357 introductions was sent to the USDA National Seed Storage Laboratory, Fort Collins, Colorado. Shipment of seeds and tubers were made to 19 States and nine foreign countries.

#### D. Culture

1. Quality Evaluation of Seedlings and Varieties. Approximately 110 seedlings and 12 named varieties grown in the early-, medium-, and late-variety yield trials and 217 advance seedlings grown in 50-hill plots were compared for yielding ability, U.S. No. 1 grade percentages, specific gravity, and chipping quality. Yields varied from 445 cwt. per acre of U.S. No. 1 tubers to 169 cwt. Specific gravity readings ranged from 1.062 to 1.092. Seedlings B3620-1, B4446-1, B4744-23, B4844-2 were all acceptable for chipping quality.

2. Cooperative Research. In cooperation with Campbell Soup Company in 1963, 25 seedlings and varieties in replicated tests and 111 advance selections in 10-hill observation plots were grown at four locations (Maine, New Jersey, Ohio, and Wisconsin). This material was evaluated for yield, specific gravity, French frying, and sloughing and translucency before and after storage at various temperatures. Approximately 350 seedlings and varieties from the USDA Breeding Program in Maine were also evaluated for use in frozen soups. The seedlings and varieties varied within and between locations in specific gravity, yield, and retained weight and translucency of their dices after freezing and thawing. Several promising seedlings were located for future use as parents and possible varieties.

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INSECT CONTROL  
Entomology Research Division, ARS

Problem. Control of insect pests is essential to the profitable production of high-quality potatoes demanded by the consumer. There is a continuing need for research to improve present control methods as insects develop resistance to insecticides and the public demands safer, more effective, and more economical methods of insect control. The overall problem is complicated in that many of the virus diseases of potatoes are transmitted by small populations of insects that otherwise would be of little importance. Sometimes it is not known which insects are responsible. It is important to learn the identity, distribution, and ecology of the vectors of diseases of potatoes in order to make an intelligent approach to the development of methods for preventing insect transmission of the diseases. There is an especial need for research on the ecology and biological control of potato insects; and for research on the evaluation of potato varieties for insect resistance. Growing concern over problems associated with insecticides which may also include adverse effects from residues in the soil, contamination of non-target areas, and interference with the work of natural enemies of insect and mite pests, makes it imperative that an increasingly strong research effort be directed to the development of nonchemical methods of insect control or of ways of using chemicals that will avoid objectionable side-chain effects.

USDA AND COOPERATIVE PROGRAM

Basic studies on the biology, ecology, and pathology of insects that attack potatoes in the field or transmit virus diseases, as well as applied research on their control are conducted by the Department at Yakima, Wash., Orono, Me., Beltsville, Md., and Charleston, S.C., in cooperation with the respective State experiment stations, the Washington Department of Agriculture, the Washington State Potato Commission, and industry.

The Federal scientific effort devoted to research in this area totals 5.6 professional man-years. Of this number 1.4 are devoted to basic biology; 2.4 to insecticidal and cultural control; 0.7 to insecticide residue determinations; 0.3 to biological control; 0.2 to insect sterility, attractants, and other new approaches to control; 0.1 to varietal evaluation for insect resistance; 0.2 to insects that spread potato diseases; and 0.3 to program leadership.

## PROGRAM OF STATE EXPERIMENT STATIONS

The State experiment stations have an effective potato insect research program underway.

The evaluation and integration of newly-developed chemicals with currently used insecticides, cultural methods, and pathogenic agents is being carried out. Information is being obtained on the influence of pesticide treatment on the development of natural enemy populations. Analyses of both tubers and soil are being performed to determine the amount of insecticide residue present following treatment and the rate of decomposition.

Studies are in progress to establish the relationship between insect-transmitted potato diseases and their vectors. The factors influencing these basic relationships are being analyzed and promising leads obtained are evaluated for their use in control.

Varietal crosses, selected seedlings, foreign varieties, Solanum species and interspecific hybrids are being evaluated for insect resistance. Resistant and susceptible strains are being studied to determine the nature of resistance mechanisms.

A total of 8.8 man-years is devoted to potato insect research in the States.

## PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Basic Biology, Physiology, and Nutrition

1. Green Peach Aphids. Stem-mother green peach aphids hatching from eggs taken from peach twigs in February were colonized successfully on Malva rotundifolia in outdoor cages where the aphid reproduced in successive, agamic generations of apterous and alate individuals. The successful transfer of stem-mother green peach aphids to herbaceous plants which had never been demonstrated before confirms the practicality of removing and burning egg-infested peach prunings from orchard ground litter early in the spring as a means of controlling the green peach aphid.

2. Wireworms. Whole-wheat, bran baits placed in wireworm-infested soil in Washington yielded more wireworms in much less time than conventional screening of the infested soil during the collection of 10,000 Limonius wireworms required for insecticide screening experiments. The same number of worms were collected in 25% of the time spent in baiting as in screening.

3. Garden Symphylan. The garden symphylan injured 90% of Red LaSoda potato tubers harvested from experimental plots at Gresham, Oreg., in 1963. Russet Burbank potatoes at Harrah, Wash., were severely damaged in 1962. Symphylan damage to potato tubers is difficult, and at times impossible, to differentiate from damage caused by larvae of the tuber flea beetle.

Five pounds of dieldrin per acre disked into the soil before planting were not effective.

4. Two-Spotted Spider Mite. Eggs and nymphs of the two-spotted spider mite were found during the winter of 1963-4 in eastern Washington on overwintering sugarbeet, peppermint, wild carrot, curly dock, and red clover. Previously it had been presumed that only the adults overwintered.

A collecting board, consisting of a 9-inch square piece of coarse, cotton filter cloth was superior to a mechanical brushing machine for evaluation of two-spotted spider mite control in miticide screening experiments on potatoes and much faster than the old method. The collecting board is held beneath the infested plants and the plants struck 5 times with the hand to dislodge the mites.

5. Millipede. A millipede, Polydesmus inconstans, was responsible for damage to Red Pontiac potatoes at Dayton, Wash., and apparently had been a pest of vegetables there for several years. It is of European origin.

#### B. Insecticidal and Cultural Control

1. Aphids. At Presque Isle, Me., under conditions of moderate aphid infestations, only one application of a foliar spray containing the experimental insecticide UC-21149 at 1/2 lb. per acre late in July was required to hold aphid infestations below the level that would result in appreciable spread of the leaf roll virus. By contrast, two applications of UC-20047 at 2.0 lb. per acre and three applications of the commercially available insecticides endosulfan at 0.5 lb./acre, endrin at 0.25 lb., and Bidrin at 0.2 lb. were required to prevent appreciable spread of this disease. Among the newer experimental materials tested as foliar sprays, the most promising was Bayer compound 41831. Promising results were also obtained with 3 experimental systemic insecticides, American Cyanamid 47031, Chemagro 39007, and Chemagro 25141.

In Washington mixtures of schradan and Di-Syston granules gave control of the green peach aphid on potatoes superior to that obtained with schradan or Di-Syston alone. In other experiments schradan mixtures with other phosphate insecticides gave excellent control of aphids. The application of Di-Syston to the soil in bands when potatoes were planted very early in the spring, or in March or the first half of April, gave poor seasonal control of the green peach aphid whereas a later side-dressing application of Di-Syston in mid-May gave excellent control.

2. Seed-Corn Maggot in Washington. Exploratory tests showed that a diluted captan dust applied to freshly cut Russet Burbank potato seed pieces at the rate of 3/4 lb. of captan per acre protected the seed against attack by seed-corn maggot. A carbaryl dust applied to the seed at 1/3 lb. of carbaryl per acre was promising for control of the maggot but stunted the plants.



3. Wireworms in Washington. Applications of Telone, ethylene dibromide, and Vidden-D fumigants and parathion and diazinon granules made to the soil the first half of April before the potatoes were planted gave excellent control of the Pacific Coast wireworm. Di-Syston granules, applied at the same rate as the other granular formulations gave poor control of the wireworms. Exploratory field tests showed that side dressings of either phorate or parathion granules made to soil after potato seed pieces had become infested with wireworm larvae would be useful as an emergency measure for protection of the crop in non-treated fields.

Two years' study indicate that diazinon is more effective for control of wireworms on light than heavy soil. Experiments conducted in heavy-textured soil containing 6-8% of organic matter at Walla Walla in 1964 showed broadcast preplant applications of granular diazinon made at 3 lb. per acre of diazinon to be non-effective for control of the sugarbeet wireworm. However, 3 lb. phorate, 4 lb. Stauffer N-2790, and 5 lb. Bayer 37289 applied as granules gave satisfactory control. In similar heavy soil at Toppenish, Wash., 4 lb. of parathion per acre applied to the soil as a preplant spray gave excellent control of wireworms whereas 3 lb. per acre of diazinon in granular form was not effective.

4. Wireworms in South Carolina. Of 46 new materials laboratory screened against the southern potato wireworm, only Stauffer B-10341, N-3727, and N-4446, and Shell Development 8803 were sufficiently toxic for further tests. In field tests, a special slow release parathion granular formulation gave 100% mortality of wireworms put in treated soil 91 days after application as compared to 5-15% mortality by the conventional parathion granules. Kepone-cornmeal bait gave promising results.

### C. Insecticide Residue Determinations

1. Aldrin-Dieldrin Residues. Further studies in Washington, Idaho, Oregon, Maryland, and South Carolina on aldrin-dieldrin residues demonstrated that under some conditions dieldrin treatments of the soil will leave as much residue in potato tubers as will aldrin treatments. Consequently, recommendations for the use of dieldrin soil treatments for potatoes were discontinued. Chemists found averages of 0.03, 0.03, and 0.097 p.p.m. of aldrin and 0.22, 0.42, and 0.69 p.p.m. of dieldrin on or in potato tubers grown in field plots in South Carolina given 2.5, 5.0, and 10.0 lb./acre, respectively, of aldrin prior to planting. Similar applications of 2.5, 5.0, and 10.0 lb./acre of dieldrin resulted in average residues of 0.17, 0.36, and 0.75 p.p.m. of dieldrin at harvest.

Emulsion-type sprays of aldrin and dieldrin at 2, 3, and 5 lb. per acre, were applied to the soil of replicated plots at Othello, Wash., Gresham, Troutdale, Prineville, and Aurora, Oreg.; and Firth, Pingree, and Idaho Falls, Idaho.; and worked into the soil before planting Russet Burbank potatoes. At harvesttime over-tolerance levels of aldrin-dieldrin

were found in potatoes from all treatments at Othello, all treatments at Troutdale except the 2-lb. aldrin treatment, and all treatments at Gresham and Troutdale but the 2- and 3-lb. aldrin treatments. Over-tolerance residues were found only in potatoes from the 5-lb. dieldrin treatment at Aurora, Oreg., and no over-tolerance was found in any treatment at Firth, Pingree, and Idaho Falls, Idaho. Evidently potatoes are more subject to residue contamination in some soils than in others. The clay and organic matter contents are thought to be important factors.

Measurable, but below tolerance, levels of aldrin were found in Russet Burbank and Red Pontiac potatoes and carrots grown the second year following broadcast applications of aldrin granules to the soil at 5 and 10 pounds per acre. Measurable, but below tolerance, levels of dieldrin were found in the potatoes and onions where 5 and 10 pounds of aldrin and 3 and 6 pounds of dieldrin had been applied. Above tolerance levels of dieldrin were found in sugarbeets and carrots in each of the 4 treatments.

2. Phosphorus Residues. Following band applications of 2-lb. rates of 3 systemic insecticides applied as granules in Washington soil at planting time, residues in potatoes at harvesttime were phorate - 0.08 p.p.m., Di-Syston - 0.09 p.p.m., and schradan - 0.27 p.p.m. No measurable parathion residues were found in potatoes treated at planting time with 3 lb. of parathion per acre. Where 3 lb. of parathion was side-dressed, one sample out of three carried a residue of 0.05 p.p.m.

#### D. Biological Control

1. Aphids. In Maine it was found that large populations of the lady beetle, Hippodamia 13-punctata tibialis, may not provide adequate control of aphids on the primary hosts in fall. The larval stage of these coccinellids is quite effective in controlling aphids on potatoes in summer, but the migrating populations of the adults in fall failed to be thorough in searching for aphids on the primary hosts.

The predominant species of parasite of potato aphids in Maine in 1963 was the same as in 1962, Aphidius nigripes. The next most abundant were two undescribed species of Praon. Of the parasitized aphids collected, 13% were affected by hyperparasites, the most common of which were Asaphes lucens and Lygocerus spp.

Fungus diseases, appearing in Maine in late July, were exceptionally effective in controlling the potato aphid and buckthorn aphid on potatoes. Identifications of the dead diseased aphids, made by the California Agricultural Experiment Station revealed that the predominant species of fungus was Entomophthora thaxteriana. Another species, Entomophthora coronata, was found for the first time since 1945. A third species, Entomophthora lageniformis, was found infecting aphids for the first time in 22 years of the survey study. These studies indicate that sublethal infections of fungi may reduce biotic potential of the aphids.

### E. Evaluation of Equipment for Insect Detection and Control

1. The six-spotted leafhopper in Washington was attracted to green light in greater numbers than to either white fluorescent or blacklight tubes in light traps.
2. Green Peach Aphids. In Washington, deep yellow paint was superior to yellow paint diluted with white for attracting winged green peach aphids in water trap pans. A few copper sulfate crystals placed in the water pans prevented growth of algae.
3. In Washington a proprietary fertilizer attachment for a tractor sold primarily to orchardists for the deep placement of fertilizers in the soil was modified slightly and proved efficient in placing systemic insecticide granules at desired depths of 3 to 21, or more, inches prior to planting potatoes.

### F. Insect Vectors of Diseases

1. Aphids in Maine. Three applications of a paraffin-base oil to young potato plants one week apart at one gallon per acre per application reduced spread of potato virus Y by 58% at Presque Isle, Me., in 1963. Most of the spread occurred after the protection provided by the oil had diminished after applications had ceased. Apparently this non-persistent virus borne externally on the mouthparts of the aphid is inactivated as the mouthparts penetrate the film of oil.

In preliminary cage tests in Maine, a foliar spray containing 1/2% chlorocholine chloride reduced spread of leaf roll by the green peach aphid 22 to 83%. The mode of action is not known. The chemical apparently penetrates the foliage as the greatest protection occurs when the plants are infested with aphids 48 to 72 hours after treatment.

2. Leafhoppers in Washington. A field bioassay of the viruliferousness of the leafhopper vectors of aster yellows in a Columbia Basin potato field revealed no inoculation of aster plants before July 3 when 15% of the plants left in the field 2 weeks became infected. Later infections ranged from 10% on July 18 and 7% on August 1.

The six-spotted leafhopper carrying a Washington strain of aster yellows caused internal discoloration in 59% of Red Pontiac potatoes produced by infected plants and 34% in Russet Burbank potatoes. In another experiment with Russet Burbank potatoes, aster yellows caused 30% discolored tubers, leaf roll 75%, and a combination of the two viruses 71%.

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## TILLAGE, PLANTING AND FERTILIZING

### Agricultural Engineering Research Division, ARS

Problem. Intensive research is needed to determine the optimum tillage requirements, based on costs and crop response, for various soil, climate, and crop conditions.

New types of fertilizers and the increasing use of irrigation in the production of potatoes has made it desirable that equipment be developed to plant at the optimum depth and distances and at the same time apply fertilizer in the optimum amount depending upon the analysis and at the most satisfactory position with respect to position of the seed piece.

### USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program of applied engineering research on planting methods and means of applying fertilizer on various crops. The Federal scientific effort devoted to research in this area totals 9.6 professional man-years, of which 0.4 is on potatoes.

### PROGRAM OF STATE EXPERIMENT STATIONS

A total of 11.7 man-years of research effort is devoted to this work on all crops; figures are not available for work on potatoes.

### PROGRESS -- USDA AND COOPERATIVE PROGRAMS

Minimum Tillage for Potatoes. Conventional pre-plant tillage takes time, costs money and may serve no value. The study of primary pre-plant tillage involving deep tillage in the Spring, deep tillage in the Fall, Fall plowing, Spring plowing, and no tillage whatsoever (planting directly in wheat stubble) was repeated for the third year. Potato yields and clod measurements were in harmony with the previous two years' results. The yield and amount of clods were not effected by pre-plant tillage practices. In fact, in all three years, potatoes planted directly in wheat stubble resulted in greater yields and slightly fewer clods. The results of this phase of the research is being prepared for publication and should be available in the summer of 1964.

On irrigated potatoes in Nevada, four fertilizer ratios plus a systemic insecticide (Thimet) for the control of sucking insects, were compared to similar plantings without the use of the insecticide. All ratios contained 180 lbs. of  $P_2O_5$  per acre, but the N was varied from 300, 200, 100, and 0 lbs. per acre. With the insecticide, the 100 lb. rate of N produced a yield equal to that from the 200 lb. rate of N without the insecticide. The  $P_2O_5$  and the first 100 lbs. of N were placed 4 in. on each side and 2 in. below the seed piece, and the additional N was top dressed when the plants were 5 in. high. By using the combined fertilizer-insecticide, the cost of production of potatoes per acre can be materially reduced - by the saving of 100 lbs. of fertilizer per acre and one trip over the field.



PEST CONTROL TECHNIQUES AND EQUIPMENT  
Agricultural Engineering Research Division, ARS

Problem. Many pests attack economic crops in the United States, resulting in billions of dollars of loss to the farmer each year. Plant diseases, weeds, insects, and nematodes are examples. Every method to control or eradicate any of these pests requires some type of equipment. Effectiveness of the equipment necessary may be essential to the success of the method which is attempted or recommended.

Thus, equipment to control a wide variety of pests on a wide variety of crops is required. This requirement is partially met by the sprayers, cultivators, dusters, and soil injection equipment now available. However, mechanical cultivation does not always produce satisfactory weed control, and it is time consuming and costly. It is believed that with sprayers and dusters now used, often no more than 10 to 20 percent of the chemical goes onto the plant. Methods of applying nematocides in the soil do not always result in uniform nematode control, and untreated soil below the treated zone, in untreated pockets, and at the soil surface, provide sources for quick reinfestation.

There is need for improved methods of much greater efficiency for applying pesticides to plants and the soil. This implies a need for considerable fundamental study of small particle behavior, of radically new methods of applying chemicals, and of the movement of liquid and gaseous chemicals in the soil. The sales of present equipment are not great enough, nor are the manufacturers large enough, to permit industry to make a very great investment for research in this field.

#### USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program involving agricultural engineers, physicists, and mathematicians engaged in both basic studies and the application of known principles to the solution of farmers' problems. Cooperation is with the State Agricultural Experiment Stations of the states mentioned, unless otherwise noted. At Wooster, Ohio, basic research is conducted on fundamental studies of aerosols and on various spray formation devices. Soil fumigation research also is conducted at Wooster, Ohio. Disease control research is also conducted at Wooster, Ohio. Pest control equipment research for potatoes is conducted at Forest Grove, Oregon.

The Federal scientific effort devoted to research in this area totals 14.4 professional man-years, of which 1.7 is devoted to basic studies in aerosols and spray formations, 1.0 to soil fumigation, 1.0 to insect and disease control by ground equipment in vegetables and other low-growing crops, and 0.9 to aircraft equipment for application of pesticides to vegetables and other low-growing crops.

## PROGRAM OF STATE EXPERIMENT STATIONS

A total of 2.7 man-years is devoted to this work on all crops; figures are not available for work on potatoes.

## PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Basic Studies in Aerosols and Spray Formation.

1. Mathematical and experimental studies on the basic transport, spreading, and distribution processes for fine particles suspended in turbulent gases were continued at the Pioneering Research Laboratory on Physics of Fine Particles at Wooster, Ohio. An instrumentation system is under development for measuring the distribution of fluorescent-traced particles on deposition surfaces to facilitate the study of relations between deposit distribution and the turbulence producing it. A method of spectral analysis has been developed which appears to be applicable to the measurement of surface deposit, but which needs further study. The use of a tape recorder has made experimental procedure immeasurably easier than if one attempted to process the "live" signal directly. Additional work is being carried forward in the areas of heat and moisture diffusion in fine-particle starch doughs, and in electrical diffusion of clay suspensions.

B. Soil Fumigation.

1. Field treatments were made in cooperation with the Ohio Station in order to study and develop methods and equipment for applying chemicals to soil for the control of crop pests. A number of volatile materials are now available in pressurized cylinders or bottles similar to the containers used for oxygen, nitrogen and other compressed gases. By using an appropriate regulator, these materials are easily applied by the field cultivator equipment with injector blades. Applications of this type made for control of Verticillium in vegetable plantings gave substantial increases in yield but the materials do not give the desired control of this disease. Measurements made of cherry trees planted in soil treated with several different nematocides in 1957 and 1960 show increased twig growth and greater spread of branches than in untreated plantings.

Applications of herbicides by a rotary tiller type of applicator, operated with forward travel per blade cut ranging from 1.5 to 4.7 in., show best result with the short cut. The short cut is believed to give a better resultant mixing of non-volatile chemicals with the soil.

Latex, asphalt and wax emulsions were applied to soil as surface mulches. This had previously been found to increase plant growth including weeds. Several formulations including different herbicides were applied. Generally these formulations appeared to produce some seedling injury and reduction in stand in vegetables on which they were used.

#### Insect and Disease Control by Ground Equipment in Vegetables and Other Low-growing Crops.

Both hydraulic and air blast sprays were applied to sugar beets in cooperation with the Ohio Station and Northern Ohio Sugar Company. Hydraulic applications were designed to study seasonal timing of spray applications, effect of interval between applications, various copper and oil combinations, and control achieved by other fungicides. Results were obscured by dry weather which prevented disease development. For example, although seven sprays of a copper and oil fungicide, beginning July 16 and applied at 10-day intervals, gave the best disease control, the yield of beets and sugar was no better than five sprays applied at 15-day intervals or three sprays at 20-day intervals.

A series of seven different air blast sprays were applied to sugar beets at 10-day intervals. Variations included gallonage applied, swath width, fungicide used, and operating pressure. Dry weather permitted little development of Cercospora leaf spot infection in the beet foliage. All treatments, therefore, gave excellent control of this disease. Manzate and copper with oil applied at comparative rates, showed a slightly higher sugar yield in favor of the former. Copper analyses were made of deposit samples taken across a 100-ft. double swath sprayed from both sides. These show a higher center deposit at a 40 gal. per acre application rate, when compared to rates of 20 and 10 gal. per acre. Other sample analyses show deposit patterns are affected by size, number, and placement of nozzles and by wind velocity and direction.

Sprays were applied to sugar beets at another location to study the effect of supplemental oils in improving the fungicidal action of fixed-coppers. The experiments indicate that increasing quantity added or viscosity of the oil, within the limits studied, increased the adhesion of copper to this foliage.

Sprays were also applied to a mixed vegetable planting to study spray adhesion on various types of foliage (pubescent or glabrous). The effect of dew and rainfall was included in this study, but extreme dry weather interfered with this part of the experiment. The results suggest that smooth foliage should be sprayed more frequently and with a higher dosage than hairy foliage, to obtain comparable disease control.

#### D. Aircraft Equipment for Application of Pesticides to Vegetables and Other Low-growing Crops.

Major project activities in 1963 included the rebuilding of a Bell 47D1 helicopter which was obtained by transfer in 1962. Operations consisted of dismantling all major components, sandblasting, overhauling, inspecting for flaws, painting and rebuilding the entire unit. Spray equipment was designed, fabricated and fitted to the helicopter and will be used in the research investigations. In February and March of 1963, an aircraft



mechanic and machinist, and an aircraft pilot, attended schools for helicopter mechanics and pilot training, respectively.

A series of bait insecticidal sprays were applied with the Rawdon T-1 airplane to a crop of peas for the control of the pea weevil in canning peas. These applications were made near Woodburn, Oregon, in cooperation with the Entomology Research Division. The flight elevation was about 25 ft. and the swath spacing 50 ft. The bait sprays consisted of brown sugar mixed in water and endosulfan or malathion and applied at the rate of 4 gal. of formulation per acre. The object of the tests was to control the insect with a minimum amount of toxicant by use of an attractant bait. In one test area the results were inconclusive. In another area 84 to 93 percent control was obtained at 48 hrs. after the application. The tests showed that the bait spray will suppress the pea weevil population on canning peas although not 100 percent was obtained.

Assistance was given to the Forest Service in conducting exploratory spray distribution tests with a helicopter owned and operated by Evergreen Helicopters of McMinnville, Oregon. The results of these pattern studies were used by the Forest Service as a basis for a series of aerial pesticide application tests with helicopters to control the Western Hemlock looper in Pacific County, Washington.

A spray distribution test series was conducted in cooperation with the Piper Aircraft Corporation using a Piper Pawnee PA-25-235 furnished by the Company. These data showed that a reasonably uniform and satisfactory deposit pattern as well as swath width could be obtained with a low density application rate (1-3 gal. per acre) when an asymmetrical nozzle arrangement was used. A satisfactory deposit pattern was not obtained for the high density applications. Tests were discontinued when the aircraft was recalled by the Corporation because of other commitments. These high density tests will be continued as opportunity permits.

A limited number of tests were conducted with a Piper Pawnee PA-25-235 aircraft owned by Sam Whitney of Newberg, Oregon. This aircraft was equipped with a hydraulically driven spray pump instead of the externally mounted windmill type drive and external mounting used by Piper Aircraft. The change in pump mounting did not appear to affect the spray pattern being deposited.

## PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

### Basic Studies in Aerosols and Spray Formation

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Brazee, R. D., and Hall, G. E. 1963. An Application of Data Smoothing by an Analog Computer. USDA, ARS 42-79 series. November.

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#### Soil Fumigation.

Wilson, J. D., Hedden, O. K., and Bailey, Carl. 1963. Soil Treatments and the Growing of Locust Seedlings. Ohio Agric. Expt. Sta. Res. Cir. 114, 31 pp.

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#### Aircraft Equipment for Application of Pesticides to Vegetables and Other Low-growing Crops.

Winterfeld, R. G., Young, V. D., Deonier, C. E., and Getzendaner, C. W. 1963. Piper PA-25 "Pawnee" Distribution Patterns. ARS 42-84. September.

## HARVESTING AND HANDLING OPERATIONS AND EQUIPMENT

### Agricultural Engineering Research Division, ARS

Problem. This area is concerned with the development of equipment and methods for efficiently harvesting and farm handling crops, with emphasis on the preservation of inherent qualities during these processes. The cost of harvesting and farm handling of most crops is the major expense of production, often amounting to over half of the total returns to the producer from the sale of the product. In addition, supply and adequacy of manpower for these operations are becoming progressively less satisfactory.

#### USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program involving agricultural engineers engaged in both basic and applied research on the engineering phases of crop harvesting and handling. Potato harvesting research, cooperative with the Red River Valley Potato Growers' Association, is being conducted at East Grand Forks, Minnesota. The Federal engineering effort devoted to research in this area totals 29.0 professional man-years, of which 2.0 is on potatoes.

#### PROGRAM OF STATE EXPERIMENT STATIONS

A total of 44.2 professional man-years is devoted to this work on all crops; figures are not available for work on potatoes.

#### PROGRESS -- USDA AND COOPERATIVE PROGRAMS

1. Mechanical injury of potatoes. Bruising continues to be one of the major problems in harvesting and handling potatoes. Studies were made to determine if there was a correlation between difference in physical measurements of potatoes (stress-strain, sheer strength and electrical conductivity) and differences in resistance to mechanical injury. No correlation could be established. Samples of freshly dug tubers were run over a bruising device. Other potatoes were taken directly from the loading elevator of a commercial harvester and evaluated for bruising. These potatoes were tested with an impact instrument. No correlation between the actual bruising and the results with the impact instrument could be established. The cantilever flap rubber cushioning for rod conveyors, given preliminary tests last year, was produced in experimental quantities for use in two commercial harvesters. One was used for 120 acres and the other for 300 acres. Results showed no design weakness and the use of the cushioning flaps resulted in less bruising and good soil separation.

2. Multi-row harvesting of potatoes. Potato harvesters have become more expensive and heavier each year. Anything which can be done to increase the acreage a unit can harvest and reduce soil compaction is desirable. The 1963 work again showed that combining direct and indirect methods of mechanically harvesting potatoes made it possible to harvest four to six rows at one time. Results show that standard two row open front style harvesters, equipped with two 29 inch or 30 inch primary aprons and two end-to-end roller shares, are adapted to the direct-indirect operation with either two or four rows windrowed between the two rows handled direct by the harvester. Triple apron open front style harvesters are not recommended because the two extra rows of apron hooks increase the hazard for that type of damage on primary aprons, and appear to have lower soil separating capacity than aprons of the same specifications except greater width (longer link span). Total capacity of a given harvester can be reached in a given yield at lower travel speeds which permits the use of lower apron speeds, more soil padding and less roll-back -- all favorable to the reduction of bruising or other mechanical damage. It is estimated that by the combination direct-indirect method, one harvester and a semi-harvester working in favorable conditions can reach a harvesting capacity of 2,000 pounds per minute and that 500 acres per season would be a conservative figure for planning purposes in the Red River Valley.

3. Dust applicator for seed potatoes. Studies conducted by pathologists have shown that cut seed treatment prevents seed piece decay. The application of chemicals by dipping these seed pieces in a solution has serious limitations. Although dusting has many advantages, no commercial equipment for uniform application insuring complete coverage of the seed piece surface is available. A laboratory device for applying dust to cut seed potatoes was constructed. Freshly cut tubers were passed through an atmosphere in which a fungicide dust was suspended. Tests with this experimental equipment revealed that an excessive amount of dust settled in the dirt separation compartment thus involving waste of dust or the alternative of screening the dust out so it could be reused. The unit is being modified so that an inclined rotating drum replaces the oscillating tray as a means of conveying the cut seed pieces.

#### PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

##### Potato Harvesting Equipment

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## II. NUTRITION, CONSUMER AND INDUSTRIAL USE RESEARCH

### Utilization Research and Development

#### Eastern Utilization Research and Development Division, ARS

Problem. The potato industry, faced with a continuing decline in the consumption of fresh potatoes, is becoming more and more dependent upon the development of new and improved processed products to maintain markets and to avoid recurring economic disasters. Crop perishability, supply fluctuations, and the inelasticity of demand, result in wide swings in price with even slight surpluses. In producing areas having a substantial processing industry, depressive lows are moderated by advance contracting by processors prior to harvest. However, in many important potato growing areas processing has not yet developed, and vulnerability not only still exists, but is exaggerated by the growing competition of processed potato and other competing food products. A continuing improvement in processed potato products is clearly required if processing is to expand fast enough to offset the progressive decline in use of fresh potatoes.

Lack of adequate knowledge concerning the chemical constituents, physical properties, and enzyme systems in potatoes is limiting development of new and improved processed products and processing methods. Basic research on composition is needed to provide fundamental information on which an applied research program can be systematically and effectively built. Recently-developed techniques make it possible to isolate and characterize the constituents responsible for flavor, color, odor, and texture of many processed food products. Application of these techniques to potatoes and potato products should make it possible to improve the quality of present products, both freshly processed and following storage, and provide a basis for technological and engineering studies in new product development.

#### USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program of basic and applied chemical and engineering research on studies related to processing. The work of the EURDD, involving the services of chemists, biochemists, food technologists and chemical engineers at Wyndmoor, Pennsylvania, is conducted in cooperation with the Maine Agricultural Experiment Station and several other stations, which supply potatoes of known cultural history. The chemical research program includes: evaluation of the effects of variety, location of production, storage conditions, and tuber solids content on potato composition with particular respect to nitrogenous constituents; principal acids and other factors related to discolorations such as after-cooking discoloration; preliminary studies on the lipids, which are believed to occupy an important role in storage stability of processed potato products, particularly dehydrated foodstuffs. The Eastern Division's engineering and development research program seeks to improve the quality, nutritive value and storage stability of dehydrated potato products and to develop more convenient types of dehydrated products, such as "instantized" pieces that cook quickly. The Red River Valley Potato Processing Laboratory, East Grand Forks, Minnesota, has been established to conduct investigations



relating variety and other raw material characteristics to quality of established forms of processed potatoes. This new Laboratory is operated jointly by the Red River Valley Potato Growers Association, University of Minnesota, North Dakota State University and the Agricultural Research Service with the Engineer-in-Charge reporting to Wyndmoor.

The Federal (EU) scientific effort devoted to this area totals 14.4 professional man-years. Of this total, research on chemical composition as related to processing characteristics comprises 8.5 p.m.y. and research on dehydrated potato products amounts to 2.5 p.m.y. Research on new and improved processing technology amounts to 3.4 p.m.y., including 1.0 p.m.y. for the Red River Valley Processing Laboratory.

#### PROGRAM OF STATE AGRICULTURAL EXPERIMENT STATIONS

For many years State stations have conducted research on problems related to potato utilization. Studies designed to evaluate, by biochemical and physical means, the effects of such production variables as fertilization, variety, location of production, harvest maturity, handling and storage on composition and use of potatoes are continuing.

The trend toward increased processing has added emphasis to work designed to evaluate processing quality of potatoes. A prime problem associated with the rapid growth of potato processing is maintaining quality of tubers during extended storage. Production variables and storage conditions affect potato composition. Mechanical harvesting systems frequently affect potato quality and composition. Yields; total solids; suitability for french frying, chipping, boiling, mashing and baking; and sugar content are routinely determined. More thorough chemical composition studies are carried out to determine content of phenolic acids, nitrogen, nitrogen-free organic acids, amino acids and reducing sugars as a means for better understanding utilization problems.

Interest in problems of discoloration and the role of nitrogenous compounds in enzymatic blackening leads to studies on the color reactions of polyphenol oxidase plus chlorogenic acid and/or caffeic acid with amino acids found in potatoes. Recently work is being initiated to determine the relationship of lipid content, both total and fatty acid composition, to discoloration of potatoes. The relationship of chemical and physical properties of potatoes to sloughing is also being studied.

New techniques for conduct of flavor investigations are applied to potatoes and potato products. For example, gas chromatographic techniques are used to study the volatile compounds of potato chips as a part of the attempt to isolate and identify the chemical compounds responsible for the flavor and aroma of chips. This work is tied in with efforts designed to find ways to maintain or extend fresh potato flavor and improve chipping quality or shelf-life.

Product research includes work designed to determine physical factors affecting the color or lack of brightness of reconstituted dehydrated potatoes. The relationship of specific gravity and starch content to the texture of frozen french fried potatoes is being investigated. Another study deals with the effect of pre-preparation, preparation, and post-preparation techniques on the quality, yield and cost of potatoes prepared in quantity.

The potato utilization research program also includes investigations designed to work out new or improved uses for sweet potatoes. New methods of processing grades currently not acceptable by the fresh market are sought. Suitability for canning, freezing and dehydration is determined. Means of using sweet potatoes in new products or other food products are investigated.

The total number of professional man-years devoted to potato utilization research is 7.7.

## PROGRESS -- USDA AND COOPERATIVE PROGRAMS

### A. Chemical Composition as Related to Processing

1. Nitrogenous constituents. Individual extractable amino acid analyses of 1962 crop samples of Katahdin, Russet Burbank, Kennebec, Red Pontiac and Cobbler grown in Maine, New York, Pennsylvania, Red River Valley area, Wisconsin and Idaho were so different from corresponding data from the 1961 crop that the 1963 crop is being included to obtain a range of values considered representative. Analyses have been completed for about one-third of the samples of the 1963 crop.

Statistical analyses of the 1959 and 1960 storage studies have been completed. With the exception of glutamine and asparagine, the twenty-odd free amino acids in potatoes change very little during nine months of storage. On a fresh potato basis the data indicates that regardless of the total solids content, the potato stores the same amount of nitrogen and amino acids.

2. Basic studies on the after-cooking discoloration pigment. Potato protein can readily take up about 10 times as much iron as naturally present in the potato. Protein extracted from the stem end of the tuber, where after-cooking discoloration is more intense, is capable of complexing more iron than protein from the bud end. This correlates with analysis of discolored potatoes where stem-end protein contains 2 to 5 times as much iron as bud end protein and the degree of blackening is greater at the stem end. Of a number of amino acids tried in a model system in place of potato protein, only arginine and gamma-aminobutyric acid produced a black product.

3. Basic studies on potato lipids. Efforts were directed to improving techniques for extracting the lipids from the potato. Freeze drying of samples of whole potatoes prior to lipid extraction is underway in an attempt to minimize presence of artifacts in the extract.

## B. Dehydrated Potato Products

1. "Instantized" pieces. Explosive puffing has been successfully applied to french fry strips and to thin slices of potato. Thin slices are now manufactured by several companies and widely used for salad, home style fries, au-gratin and scalloped potatoes. "Instantizing" is expected to cut the time of home preparation of such foods to about one-fourth that currently required.
2. Flakelet product. Blending 20% by weight of dry skim milk with dried flakelets makes it possible to use boiling (instead of tempered) water in reconstitution of the dry mix to a mashed potato product.

## C. New and Improved Processing Technology

1. Texture and color of french fries. Physical tests and chemical analyses on raw potatoes and on corresponding french-fried samples were determined for four varieties of potatoes from the Red River Valley. Horticultural Crops Branch, AMS, is collecting data on sub-samples of the four varieties. Frying temperature and other processing variables are being investigated.
2. New Laboratory. The Red River Valley Potato Processing Laboratory was occupied by the cooperators as of March 24, 1964. Arrangements have been made with the Red River Valley Potato Growers Research Farm to plant required acreage of specified varieties desired for experimental work.

## PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

### Chemical Composition as Related to Processing

Fitzpatrick, Thomas J., Talley, Eugene A., Porter, William L. and Murphy, Hugh, J. 1964. Chemical composition of potatoes. III. Relationships between specific gravity and the nitrogenous constituents. American Potato Journal, 41, pp. 75-81.

Heisler, E. G., Siciliano, James, Treadway, R. H., and Woodward, C. F. 1963. After-cooking discoloration of potatoes. Iron content in relation to blackening tendency of tissue. J. Food Science, 28, pp. 453-459.

### Dehydrated Potato Products

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Utilization Research and Development  
Western Utilization Research and Development Division, ARS

Problem. The potato industry, faced with a continuing decline in the consumption of fresh potatoes, is becoming more and more dependent upon the development of new and improved processed products to maintain markets and to avoid recurring economic disasters. Crop perishability, supply fluctuations, and the inelasticity of demand, result in wide swings in price with even slight surpluses. In producing areas having a substantial processing industry, depressive lows are moderated by advance contracting by processors prior to harvest. However, in many important potato growing areas processing has not yet developed, and vulnerability not only still exists, but is exaggerated by the growing competition of processed potato and other competing food products. A continuing improvement in processed potato products is clearly required if processing is to expand fast enough to offset the progressive decline in use of fresh potatoes.

To improve the quality of processed potatoes, ways must be found to eliminate the stale, earthy, rancid, green, and warmed-over flavors that are sometimes encountered in potato products, including dehydrated mashed potatoes, dehydrated diced potatoes, frozen French fries, frozen patties, and potato chips. Equally important, methods must be devised to retain the desirable natural flavor of the freshly cooked potato in the processed product. Recently developed research methods offer an opportunity to isolate and identify the constituents responsible for the natural flavors and the off-flavors, to develop rapid and sensitive analytical methods for their measurement, and to determine the raw material factors controlling formation of the various desirable and undesirable constituents in the fresh potato. Further improvement in the texture of potato products is also needed. Fundamental histological and chemical investigations could be used to determine the causes of differences in the texture of potatoes, as a basis for developing improved processing methods. Enzymes play a great part in the entire compositional pattern of the potato, not only the constituents responsible for flavor, off-flavor, color, and texture, but also those responsible for disorders such as black spot. Black spot causes severe losses both to those who market potatoes fresh, and to those who process potatoes, because trimming costs are sharply increased and yields reduced. Increased knowledge of enzymes is needed as a basis for solution of the black spot and similar problems, to increase use of potatoes by reducing costs, and to improve quality of both fresh and processed potatoes.

USDA AND COOPERATIVE PROGRAM

In the Western Utilization Research and Development Division, basic and applied research on potato products is conducted at the Division headquarters at Albany, California, and by grant funds under P.L. 480 in England and



Sweden. The chemistry of potato flavor and the compounds involved in deterioration of potato products are studied to provide a basis for new and improved potato processes and products. Histochemical studies are conducted to elucidate factors involved in the texture of potato products. Basic investigations on the enzyme systems involved in potato product discoloration and the mechanism of rancidity development are in progress.

The Federal program of research in this area totals 6.3 professional man-years. Of this number, 3.4 are assigned to chemical composition related to flavor, color, and texture of potato products and 2.9 to technological and engineering research on new products and processing methods. In addition, the Division sponsors two research grants under P.L. 480 on basic studies.

#### PROGRAM OF STATE EXPERIMENT STATIONS

For many years State stations have conducted research on problems related to potato utilization. Studies designed to evaluate, by biochemical and physical means, the effects of such production variables as fertilization, variety, location of production, harvest maturity, handling and storage on composition and use of potatoes are continuing.

The trend toward increased processing has added emphasis to work designed to evaluate processing quality of potatoes. A prime problem associated with the rapid growth of potato processing is maintaining quality of tubers during extended storage. Production variables and storage conditions affect potato composition. Mechanical harvesting systems frequently affect potato quality and composition. Yields; total solids; suitability for french frying, chipping, boiling, mashing and baking; and sugar content are routinely determined. More thorough chemical composition studies are carried out to determine content of phenolic acids, nitrogen, nitrogen-free organic acids, amino acids and reducing sugars as a means for better understanding utilization problems.

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New techniques for conduct of flavor investigations are applied to potatoes and potato products. For example, gas chromatographic techniques are used to study the volatile compounds of potato chips as a part of the attempt to isolate and identify the chemical compounds responsible for the flavor and aroma of chips. This work is tied in with efforts designed to find ways to maintain or extend fresh potato flavor and improve chipping quality or shelf-life.

Product research includes work designed to determine physical factors affecting the color or lack of brightness of reconstituted dehydrated potatoes. The relationship of specific gravity and starch content to the texture of frozen french fried potatoes is being investigated. Another study deals with the effect of pre-preparation, preparation, and post-preparation techniques on the quality, yield and cost of potatoes prepared in quantity.

The potato utilization research program also includes investigations designed to work out new or improved uses for sweet potatoes. New methods of processing grades currently not acceptable by the fresh market are sought. Suitability for canning, freezing and dehydration is determined. Means of using sweet potatoes in new products or other food products are investigated.

The total number of professional man-years devoted to potato utilization research is 7.7.

#### PROGRESS -- USDA AND COOPERATIVE PROGRAMS

##### A. Chemical Composition Related to Flavor, Color, and Texture of Potato Products

1. Flavor Stability. The inclination of dehydrated potato products to oxidative deterioration is a serious commercial problem. Most unstable food products keep better under refrigeration. However, at least three large commercial trials at stabilizing potato granules or flakes by refrigeration have failed, apparently because temperatures as low as 0° did not prevent rancidification. Antioxidants are now used in most commercial dehydrated potatoes. Such use of antioxidants was guaranteed to the public domain by a Department Public Service Patent granted about 10 years ago.

Over the past several years techniques were developed to use gas-liquid chromatography to follow oxidative changes in dehydrated potatoes. An intensive stability study is in progress using gas-liquid chromatography and taste panels to measure oxidative changes in potato granules of three moisture levels at five storage temperatures in atmospheres of air and of nitrogen. Oxidative rancidity, as measured both chemically and organoleptically appears faster (1) at higher temperatures, (2) at lower moisture contents, and (3) in the air package atmosphere rather than in nitrogen. For comparison, samples were packed in an atmosphere of oxygen, where oxidation proceeded so rapidly that no realistic stability tests were possible. Under these conditions temperature had little effect. Even at -20° F. oxidation was very apparent in three months and proceeded only at a slightly lower rate than replicate samples stored at 70° F. Because the oxidation of dehydrated potatoes is believed to be closely tied to the lipid components, a comprehensive basic investigation of potato lipids is required and will be brought into the potato research program in the future.

Related basic research on the autoxidation of fats in systems that exist in dehydrated vegetables is being conducted under P.L. 480 grant at the Swedish

Institute for Food Preservation Research, Gothenburg, Sweden. The oxidation measurements are based on oxygen consumption from the headspace over fatty acid solutions used as model systems. The conventional Warburg apparatus was not suitable for studies at low oxygen pressures so a modified system was developed by which consumed oxygen from the headspace is automatically replaced by electrolysis and the rate of electrolysis is recorded. Satisfactory results are being obtained and measurements are being conducted with linoleic acid emulsions and linoleate solutions.

2. Enzymic Browning. Basic studies of the enzymic browning of potatoes are in progress at the Low Temperature Research Station in Cambridge, England, supported by P.L. 480 grant funds. The research is aimed at determining the nature, distribution, and mode of action of enzymes responsible for discoloration of uncooked potatoes and potato products, and to determine the nature and distribution of the phenolic enzyme substrates and the pathways of their synthesis. Variety, climatic factors, and cultural practices were investigated to determine their effects on the enzymic browning of cut potatoes. The major rate determining factor of enzymic browning appeared to be the concentration of tyrosine in the tuber. The level of tyrosine in the potato was demonstrated as being influenced by genetic, climatic, and to a lesser extent, cultural factors. Of the climatic factors, rainfall or the moisture available to the plant appeared to be the most important. No direct correlation was found between the rate of browning and the activity of the phenolase enzyme or the amount of chlorogenic acid (a phenolic enzyme substrate widely found in plant material). In basic comparative studies, phenolases and phenolase substrates from plant material other than potatoes, are under investigation. Phenolase from the broad bean (Vicia faba) was shown to differ from potato phenolase mainly as it may be activated or inhibited by specific reagents. Potato enzyme was active over a wider range of substrates. Sodium chloride and other salts inhibited the potato enzyme most effectively at a different pH than the enzyme of the broad bean.

3. The Role of Sulfur Dioxide in Dehydrated Vegetables. A basic investigation of the chemical mechanisms involved in the protective action of sulfur dioxide against browning of dehydrated vegetables was concluded at the Covent Garden Laboratory in London, England, where it had been supported by P.L. 480 funds. This highly successful investigation resulted in 10 scientific publications and led to the following broad conclusions:

- (1) For non-enzymic browning to occur rapidly, the presence of a sugar is less important than the presence of an amino acid or similar type of nitrogen-containing compound;
- (2) A common class of intermediates in several types of browning reactions originated from widely different compounds. These highly reactive intermediates (alpha-beta-unsaturated aldehydes) are frequently a point of departure for further reactions with nitrogen compounds, leading to brown polymers;



(3) In model chemical systems and to some extent in vegetable systems, the mode of action of several inorganic ions in modifying sugar-amino acid browning rates can be related to the effect of these ions on the initial reactivity of the sugar component;

(4) In retarding non-enzymic browning bisulfites are involved in more than one type of reaction;

(5) Two modes of bisulfite action were identified during this work that had not previously been reported. First, bisulfite lowered the initial reactivity of the sugar by affecting the relative concentrations of the isomeric forms of the sugar molecule. Second, bisulfite reduced all those browning reactions that involve alpha-beta-unsaturated aldehydes as intermediates.

(6) Indications exist that reactive intermediates can form various cyclic structures which may be incorporated in brown polymers. The polymers so formed have groups which give them ion exchange properties for metallic ions.

#### B. Technological and Engineering Research on New Products and Processing Methods

1. Frozen French Fried Potatoes. Frozen potatoes make up nearly a third of all the frozen vegetables produced in the United States. Well over a billion pounds of potatoes are utilized for frozen foods each year. About 85% of the frozen potato products are frozen french fries and of these nearly three-quarters are packaged for institutional sale. Although it is not recommended, small restaurants with inadequate freezer space commonly hold several days' supply of frozen french fried potatoes in the refrigerator at above freezing temperatures where deterioration in flavor and texture readily occur. The stability of oil-blanched frozen french fried potatoes at a storage temperature of 55° F. was investigated. A taste panel gave significantly lower scores in flavor, texture, and color to products that had been finish-fried in deep fat after three days' storage at 55° F. than to french fries that had been held at 0° F. Gas-liquid chromatography showed an increase in the hexanal peak with increased storage time. Microbial counts increased by seven orders of magnitude over five days. Stability studies will continue at temperatures intermediate between the 55° F. and freezing. It is probably too expensive for some small restaurant operations to keep french fried potatoes frozen. The results of this investigation will provide information on safe limits of temperature and time for the restaurant handling of frozen potato products.



## PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Chemical Composition Related to Flavor, Color, and Texture of Potato Products

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- Self, R., Land, D. G., and Casey, J. C. 1963. Gas chromatography using capillary column units for flavour investigations. J. Sci. Food Agr. 14(4), pp. 209-220. <sup>1/</sup>

Technological and Engineering Research on New Products and Processing Methods

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<sup>1/</sup> Research supported by P.L. 480 funds.

## NUTRITION AND CONSUMER USE RESEARCH

Consumer and Food Economics Research Division, ARS  
Human Nutrition Research Division, ARS

Problem. The assortment and characteristics of foods available to consumers are constantly changing with the adoption of new production, processing, and marketing practices. Constantly changing also, as nutrition science advances, is our understanding of the nutritional needs of man and the manner in which these needs can best be met by food. To help meet the Department's responsibility to advise consumers on the quantity and variety of foods that will assure maximum benefit and satisfaction, research must continue on the nutritional requirements of persons of all age groups, and on the nutrient and other values of foods and on how to conserve or enhance these values in household preparation and processing. Periodic surveys of the kinds and amounts of foods consumed by different population groups and individuals also are essential for evaluation of the nutritional adequacy of diets and to give the guidance needed for effective programs of nutrition education. Information from such surveys provides assistance needed in market analyses for different commodities and in the development and evaluation of agricultural policies relating to food production, distribution, and consumer use.

## USDA AND COOPERATIVE PROGRAM

The Department has a continuing program of research concerned with (1) nutritive and other consumer values of raw and processed foods as measured by chemical or physical means and by biologic response; (2) effects of household practices upon the nutritive values and inherent qualities of foods, and the development of principles and improved procedures for household food preparation, care, and preservation; (3) surveys of kinds, amounts, and costs of foods consumed by different population groups and the nutritional appraisal of diets and food supplies; and (4) development of guidance materials for nutrition programs.

The research is carried out by two divisions of the Agricultural Research Service -- the Human Nutrition and the Consumer and Food Economics Research Divisions. Most of the work is done at Beltsville and Hyattsville, Maryland; some is done under cooperative or contract arrangements with State Experiment Stations, universities, medical schools, and industry. The total Federal scientific effort devoted to research in these areas total 63.3 man-years. It is estimated that approximately 1.0 man-years is concerned with studies related to potatoes and potato products.

Human metabolic studies and the related exploratory and confirmatory studies with experimental animals and microorganisms concerned with defining human requirements for nutrients and foods are not reported on a commodity basis, though some of the work is applicable to this report. This basic nutrition research represents a total Federal effort of 26.7 professional man-years and is described in detail in the report of the Human Nutrition Research Division.

## PROGRAM OF STATE AGRICULTURAL EXPERIMENT STATIONS

### Nutrient Value of Food

Food composition and nutritive value is most frequently related to indigenous agricultural products. Specific and locally grown raw products are being extensively evaluated for essential nutrients, especially in Hawaii and Puerto Rico. Much work is related to changes induced by growing practices, processing and storage.

Certain raw products are being evaluated for their significant vitamin contribution to nutrition. The effect of production and processing practices on vitamin content continues as an area of interest. Additionally, research has been directed toward the study of vitamins in foodstuffs as affected by inhibitory and stimulatory factors.

The total program in this area includes 36 projects in 23 States and is comprised of 23.4 professional man-years.

### Properties Related to Quality and Consumer Use of Food

In the area of food preparation, products are related to quality by some measure. Special measures characterize certain classes of products; i.e., vitamin assays, enzymatic activity, water binding capacity, and changes in structural tissues. Combinations of these are involved in the quality evaluation work reported.

Comparative studies are being carried out on fruits and vegetables processed by freezing, canning and irradiation. The effect of pre-freezing treatments, as blanch and non-blanch of vegetables on the quality after quick-freeze, is under study.

Food preparation research focusing on products for home use include: Microwave preparation of meats, fruits and vegetables, including the chemical alterations involved; and flavor characterization in frozen and stored products by means of vapor component identification.

Many of these same factors are under study in institutional preparation where the quantities involved impose special conditions.



This portion of the program includes 52 projects in 21 States and is comprised of approximately 50.1 professional man-years. This is a partial report of the State Experiment Station programs in food science and includes work undertaken by home economics departments. For research on food and fiber utilization see reports of the Utilization Research and Development Divisions.

#### Food Consumption and Diet Appraisal

The State program in food consumption and dietary appraisal extends the work of the Department to other segments of the population or to geographic areas not separately identified in the nationwide studies. Currently 12 States are contributing to this program. One regional project is designed to yield information regarding food purchase and consumption patterns of families with preschool children. This group represents about one-fourth of the households in the North Central Region where the study is being made. Food habits will be evaluated in terms of the children's dietary needs. This research will provide information useful to both consumer and market interests. In the Western Region ongoing research on consumer satisfaction with selected vegetables and fruits is nearing completion.

The State program in this area totals 22.2 professional man-years.

### PROGRESS--USDA AND COOPERATIVE PROGRAMS

#### A. Nutrient Value of Food

1. Tables of food composition. Research for the newly revised Agriculture Handbook No. 8 "Composition of Foods...raw, processed, prepared" has been supplemented by further research during the year and adapted to the needs of special projects.

Formulas and procedures that were used in calculating the nutritive values of 250 food items commonly prepared at home are being summarized in a publication for special users, particularly therapeutic dietitians and medical research workers. A table showing average adjustments for vitamin losses during cooking has been developed and will be included in the publication.

Selected data from revised Handbook No. 8, have been made available in decks of punched cards and magnetic tape for research workers. Arrangements have been made for the sale of the cards and the tape by a private data processing firm in Washington.

Tables for the Department of Defense have been prepared on the composition of 630 food items procured by the Defense Supply Agency for feeding military personnel. Values for the composition of foods developed for Handbook No. 8 and many additional values provided by the Department of Defense were used to develop the data needed for the numerous special food products meeting military specifications.



2. Vitamins. Analyses for the vitamin B<sub>6</sub> content and distribution in vegetables, including potatoes, and in meats available to and as eaten by consumers, are in progress. Analyses of cereal foods, fruits, nuts, and cheeses are nearly completed and manuscripts are in progress.

A fluorometric procedure for the determination of pyridoxine as pyridoxal cyanohydrin was developed. The reactions were quantitatively reproducible over a range in concentration of 1 millimicrogram to 1 microgram per milliliter. Procedures for chemical assay for pyridoxal and pyridoxamine previously had been developed in this laboratory. Present studies are to adapt chemical procedures to analyze food extracts for the three forms of vitamin B<sub>6</sub>. The procedures are expected to provide a more constantly reliable method for measuring this vitamin. Values from the chemical procedures are being compared with values obtained by microbiological determinations for vitamin B<sub>6</sub> in foods.

Development of coordinated procedures for B-vitamins analyses continued with emphasis on a rapid, stable chemical method for nicotinic acid.

3. Carbohydrates. Research is continuing on improving and applying to various foods methods for analyses of individual sugars. Studies are concerned with extraction procedures, the determination of total and reducing sugars by conventional methods, and glucose and fructose by differential oxidation. Thin layer chromatography has been used for the separation and identification of some individual sugars from fruit and vegetable extracts.

Total and reducing sugars, sucrose, dextrin, and starch content of dry fat-free solids of composites representing 14-day diets for 16 to 19-year-old boys were determined. The diets were based on USDA food plans at moderate cost. Variations among, and correlation coefficients between, different carbohydrate fractions were calculated. Sucrose content varied more than any other carbohydrate constituent. Variations among other carbohydrate constituents were not considered to be nutritionally important. A manuscript presenting these findings has been prepared for publication.

## B. Properties Related to Quality and Consumer Use of Potatoes

1. Use of agricultural chemicals. The flavor of several varieties of potatoes grown in pentachloronitrobenzene-treated (PCNB) soil was evaluated in relation to the flavor of potatoes grown in untreated soil. No off-flavors were reported when potatoes were grown in soil treated with 12.5 or 25 pounds of active PCNB per acre at North Dakota in 1960. Off-flavors were found for potatoes grown in Maine in 1960 with PCNB treatment of 20 pounds active ingredient per acre, and with 50 pounds active ingredient per acre in Maine and North Dakota in 1959 and in New Jersey in 1961. A manuscript has been prepared.

2. Food distribution programs. Revision of the publication "Quantity Recipes for Type A School Lunches" (PA 631), was completed in cooperation with the Agricultural Marketing Service and the Fish and Wildlife Service, U. S. Department of Interior. This recipe card file provides 324 quantity recipes or variations and other information needed in preparing Type A lunches in schools participating in the National School Lunch Program. Recommendations on preparing, storing, and handling a wide variety of fruit, vegetable, cereal, dairy, meat, and poultry products were updated to take into account recent research findings and technology. New recipes were tested and evaluated, and all formulas and yields were recalculated in line with the 1964 revision of PA 270, Food Buying Guide for Type A School Lunches.

### C. Food Consumption and Diet Appraisal

1. Planning for proposed nationwide survey, households and individuals. A nationwide survey of household food consumption and of the food intake of individuals is scheduled for 1965. Plans have been developed for a survey that would provide at least 6,000 household schedules and 10,000 individual schedules in the spring of the year with smaller household samples in each of the three succeeding seasons. The information on the week's food use to be obtained from each household is similar to that obtained in 1955, except that information on home baking practices will not be requested and information requested on home food production, home canning and home freezing will be reduced to allow interview time for questions on the food intake of individual members of households.

In preparation for the proposed first nationwide survey of the food intake of individuals, data obtained by recall on the 1-day intake of food from nearly 550 individuals of all ages in Washington, D. C. during June and July 1963, have been studied in relation to two controversial issues that concern collection of data. The survey findings indicate that for this group: (1) the nonresponse rate on food intakes from individuals is not influenced by taking a schedule on household food consumption first in comparison to taking none, nor is it influenced by taking a schedule on food intakes from half in comparison to all individuals in the family; and (2) homemakers report the amounts of food eaten by family members in terms of their individual servings far more often than as proportions of household amounts. Tabulations of the Washington data also are useful as a pretest for tabulation of the nationwide survey.

2. Effects of food distribution programs on diets of needy families. A survey of the food consumption of more than 800 households that were not participating in the food stamp program in St. Louis was made in May and June 1964 to determine the relation between usual family food expenditures and payments required for food coupons. Homemakers were asked also why their families did not participate in the program. Results of the analysis

will guide the Department in revamping the St. Louis stamp program to make it more acceptable to eligible families and yet keep it within the limits of the program. Because of interest in the nutritional quality of food consumed by low-income families, an assessment may be made later of the dietary levels of these families. This is the sixth in a series of USDA food program surveys made in cooperation with the Marketing Research Division, ERS to assist the AMS to administer the food stamp and direct distribution programs.

3. Food consumption of the rural population in Spain (P.L. 480 research).

A survey of the food consumption of the rural population in Spain has been initiated by the Spanish Ministry of Commerce under the cooperative sponsorship of the Economic Research Service and the Agricultural Research Service, using P.L. 480 funds. The study will provide information needed in appraising potential markets in Spain for U. S. farm products and should yield information useful to U. S. authorities on efficient ways of improving nutrition in low-income areas. The Spanish Ministry of Commerce expects to obtain much useful information on which to base a program for improving the diets of rural families, especially through better distribution of food. Information on food consumption, income levels, and related socio-economic characteristics has been obtained from about 1,200 rural families in 6 major regions of Spain. In summarizing the results, emphasis is being placed on (1) determining the nutritional shortages among these rural families at different income levels in the different regions, and (2) computing income elasticities for different foods as well as total food consumption.

4. Effect of socio-economic factors on food intakes of individuals. Under a cooperative agreement with the Minnesota Agricultural Experiment Station intensive analysis of data previously collected showed: (1) That intakes of vitamins A and C from food by 9- to 11-year-old Ohio children increased with family income, and at each income level, a larger proportion of urban than farm children had food that provided recommended amounts of vitamins A and C, and (2) children whose food was supplemented by vitamin A and C concentrates in general did not need them as they were in "nutrition conscious" families that provided the children with foods that were high in these vitamins.

5. Nutritive value of national food supply. The nutritive content of the per capita food supply is calculated each year from estimates of quantities of foods consumed (retail weight basis) as developed by the Economic Research Service. This series, which begins with the year 1909, is being completely revised to incorporate newest estimates of per capita consumption, revised food composition data from Agriculture Handbook No. 8, and new information on the nutrients added to foods by enrichment and fortification.

A survey conducted by the Bureau of the Census for the Consumer and Food Economics Research Division has provided information for the years 1957-61, on quantities of enrichment ingredients supplied to processors to fortify flour and cereal products. Through this program about one-third more thiamine, one-fifth more iron and niacin and one-tenth more riboflavin are added to the Nation's diet than would be available if foods were not enriched.



For the first time, the enrichment survey was extended to include information on the quantities of ascorbic acid and vitamins A and D added to foods, thus furnishing a base line for future surveys. Currently the amount of ascorbic acid added to foods would be enough to increase the level in the per capita food supply by 5 percent. The contribution from synthetic vitamin A is 7 percent of which 6 percent is added through margarine. Vitamin D is not at present included in nutrient estimates.

6. Household practices in home freezer management. Recording forms and questionnaires for obtaining data on management practices of urban and rural home freezer owners were pretested and necessary revisions were made in preparation for data collection among households in Fort Wayne, Ind., and a nearby rural area. Information will be obtained in two seasons on the kinds, amounts, sources, prices, and turnover rates of frozen foods stored in the home. Such data will provide information needed to develop guidance materials for improved management of home freezers.

7. Development of food budgets and other basic data for food and nutrition programs. Interpretation of nutrition research findings and their application to practical problems has continued as part of an ongoing program to assist nutritionists, teachers, health workers, and other leaders concerned with applied nutrition programs or nutrition policies. Information developed under this program is provided to many groups both within and outside the Department working on practical food programs, on questions relating to nutritional requirements, food consumption, nutritional importance of specified foods, and on nutrition education. Increased emphasis has been given this year to opportunities for disseminating information to the public through TV and radio, the press, conferences, workshops, and the Department's Food and Home Fair.

Food budgets at different cost levels for individuals and families are priced quarterly for publication in Family Economics Review as a continuing service to welfare workers, extension agents, and others needing this information. For example, in June 1964, the cost of one week's food for a family of four including 2 school-aged children, was estimated to be \$24.40, \$32.80, and \$37.40, respectively, for the low-cost, moderate-cost, and liberal plans.

The food budgets published in Home Economics Research Report 20, "Family Food Plans and Food Costs," have been reexamined in the light of revisions in food composition data (Handbook 8, revised) and in recommended dietary allowances of the National Research Council. Some modification in food quantities was needed for certain individuals. This has necessitated revision of food plans and their presentation in technical and popular publications, including Agriculture Handbook 16, "Planning Food for Institutions," now being readied for publication. The "Food Purchasing Guide for Group Feeding," formerly a part of Agriculture Handbook 16, is in the final stages of editing for publication as a separate handbook.



All other existing guidance materials for nutrition programs were reviewed in light of the changes in recommended dietary allowances and in food composition data. Some publications have been revised; others will be updated for the next reprinting.

Nutrition Program News, a bimonthly periodical prepared for members of State nutrition committees and other community nutrition workers provides one channel for disseminating pertinent information about Federal programs and for reporting nutrition activities in the States. Issues this year included such diverse subjects as a report of the World Food Congress held in Washington, June 1963, "Levels on food products--the protection they give," and "Nutritional fitness for teenagers." Assistance to workers in nutrition programs has been provided also through consultation and program participation by staff nutritionists.

#### PUBLICATIONS--USDA AND COOPERATIVE RESEARCH

##### Nutrient Value of Food

Watt, B. K., and Merrill, A. P. April 1964. Composition of Foods...raw, processed, prepared. Agriculture Handbook No. 8. Revised December 1963. 190 pp.

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#### Properties Related to Quality and Consumer Use

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#### Food Consumption and Diet Appraisal

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Adelson, S. F., Delaney, I., Miller, C., and Noble, I. T. 1963. Discard of Edible Food in Households. Jour. Home Economics 55(8): 633-638.

Redstrom, R. A., Davenport, E. and Murray, J. 1963. Consumer Practices in the Handling and Storing of Commercially Frozen Foods, Two Cities, Two Seasons. Home Economics Research Report 23, 27 pp.

Consumer and Food Economics Research Division. Cost of 1 Week's Food at Home. Family Economics Review. Sept., Dec. 1963; April, June 1964.

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### III. MARKETING AND ECONOMIC RESEARCH

#### MARKET QUALITY

Market Quality Research Division, ARS

Problem. The problem arising from the numerous potato varieties, areas of production, seasons of harvest and special storage and handling requirements for specific uses require a continuing program of research on handling, storage, transportation, physiology, wastage control and quality measurement. The increased demand for potatoes to be used for chips, frozen french fries and other processed forms has created special problems to prevent undesirable chemical changes due to low temperatures during storage and transport. The use of higher temperatures has brought on additional problems of moisture loss and of bacterial and fungal decay. Higher temperature storage also calls for control of sprouting, with increased emphasis on chemical sprout inhibitors. Objective indices are needed to identify quality factors that are important for specific product usage and relate measurable characters of the raw product to quality of the processed product. Also needed are instruments for non-destructive detection and rejection of potatoes with internal disorders during grading.

#### USDA AND COOPERATIVE PROGRAM

The Department has a long-term program involving horticulturists, plant pathologists and plant physiologists engaged in applied and basic research. The work at East Grand Forks, Minnesota, is conducted in cooperation with the Minnesota and North Dakota Agricultural Experiment Stations and the Red River Valley Potato Growers Association. The work at Presque Isle, Maine, is in cooperation with the Maine Agricultural Experiment Station. Research on transportation of early potatoes for chips is conducted by the Fresno, California, station. The studies at Beltsville involve specialized storage problems and basic research. Studies on market diseases are conducted at Chicago and Belle Mead, New Jersey.

The Federal scientific effort devoted to research in this area totals 6.0 professional man years. Of this number 1.0 is devoted to objective measurement of quality, 0.5 to handling and packaging, 1.5 to storage, 0.5 to quality maintenance during transportation, 0.5 to postharvest physiology, 1.5 to postharvest disease control, and 0.5 to program leadership.

Work terminated included projects on the effect of ventilation on quality (MQ 2-35); prestorage treatments on potato diseases (MQ 2-39); and market quality of southeastern potatoes (MQ 2-50). Some of the work formerly conducted under MQ 2-35 and MQ 2-39 is being conducted under new line projects (MQ 2-90 and MQ 2-92).

## PROGRAM OF STATE EXPERIMENT STATIONS

Market quality research of potatoes at the State stations concerns potato storage; evaluation of the effect of varieties, and of cultural, handling, and storage techniques on processing quality; and control of disease in storage and in the marketing channels. Storage research involves studies of sprout controlling chemicals and methods of application, optimum storage temperatures and humidities, forced air ventilation and air movement, and the response of varieties to storage conditions.

Studies related to processing quality include evaluation of breeding lines and new varieties for processing quality. Research is in progress on the causes and remedies for after harvest darkening of potatoes. Physical and chemical properties of potato tissue in relation to sloughing are being investigated. Other research involves the relation of processing technique and chemical composition to the quality of potato chips, and the effect of extended storage on potato texture. Methods are being devised for storing whole unpeeled and peeled potatoes and sliced potatoes in various gases and at different temperatures to maintain reducing sugars at a low level.

Disease investigations include studies of potato scab, bacterial ring rot, other bacterial and fungal diseases, identification and control of potato virus diseases and determination of the effect of such diseases on yield and market quality, and biochemical and other studies for the control of nematode diseases of the potato.

Total market quality research effort on potatoes at the State stations is approximately 6.7 professional man-years. There are 25 projects in 13 States contributing in whole or in part to this research.

## PROGRESS -- USDA AND COOPERATIVE PROGRAMS

### A. Objective measurement of quality

1. Predetermining Processed Quality in Potatoes. Work on relating characteristics of the fresh product to frozen french fry quality is just getting under way at Beltsville in cooperation with EURD. (MQ 3-56)

### B. Quality maintenance in handling and packaging

1. Mechanical Injury Incident to Sizing Potatoes into Storage. Increases in bruising of Pontiac and Norland potatoes during sizing into storage at East Grand Forks were minor with Size A tubers, but were of some concern with large jumbo sized tubers. (MQ 2-78)



2. Stone Separation. Two varieties of whole seed subjected to a simulated water flume-stone trap operation and then shipped from Maine to West Virginia reacted no differently when planted in the field than comparable potatoes handled dry. (MQ 2-93)

### C. Quality maintenance in storage

1. Storage Temperature on Processing Quality. Evaluation of the effects of storage temperatures on the flake quality of Red River Valley potatoes was continued. Specific gravity, production of flakes per minute and the percent yield of dried flakes were not affected by the storage temperatures used (40°, 45°, and 55° F.). Potatoes stored at 40 and 45° F. were reconditioned before processing. Acceptable flakes were made of all four varieties tested during storage from January until the end of July. (MQ 2-69)

2. Methods and Rates of Ventilation on Quality of Maine Potatoes. Almost complete control of storage rot was obtained in both 38° F. (bin) and 45° F. (bin and pallet box) storages with through ventilation rates of 1 to 4 cfm per barrel. Weight losses in 45° F. bin storage ranged from 9.5% in bins with no forced air circulation to 12.5-14.0% in bins with forced-air circulation. Weight losses in pallet boxes average 6.5%. In 38° F. bin storage the weight losses ranged from 6% in the bins with no forced air circulation to 8-10% for the bins with forced air circulation. In general, weight losses increased as the airflow rates increased. The amount of injury due to pressure in the 45° F. bin storage increased as the airflow rates were increased. Internal black spot increased as the percent of severe pressure spot increased. (MQ 2-92)

3. Control of Sprouting of Potatoes. After 5 months at 60° F. and high humidity Isopropyl N-(3-chlorophenyl) carbamate (CIPC) dipped potato tubers had no external nor internal sprouts. Untreated tubers stored in same chamber with CIPC dipped tubers in laboratory storages at Beltsville developed 10 percent internal sprouting and 196 grams of external sprouts per 100 tubers. Untreated tubers in potato cellar storages in which no sprout inhibitor was used, had 0.1 percent internal sprouting and 1224 grams per 100 tubers of external sprouts. Apparently, under some conditions, low levels of CIPC may stimulate internal sprouting but if the concentration is high enough to control external sprouting, internal sprouting is also controlled.

In tests in Maine, there was no detectable difference in residues of CIPC when applied with a "Swingfog" applicator using nozzle opening diameters of 0.8, 1.1, and 1.4 mm.

A new sprout inhibitor, 2,6-dichlorobenzonitrile, (Casoron) was tested at Beltsville. When applied at concentrations of 1, 10 and 20 ppm to potatoes going into storage it did not control sprouting. The same quantity of chemical vaporized in the atmosphere surrounding the potatoes caused severe necrosis in the tubers. (MQ 2-31)

#### D. Quality maintenance during transportation

1. Transit Temperatures of California Potatoes. An early-season shipment (May 28) of Kennebec potatoes from Kern County, California to the mid-west using the conventional protective service, Standard Ventilation without ice, resulted in an average transit temperature of 51° F. and dark, unattractive chips. Another shipment made on June 2 averaged 60° in transit and produced desirably light colored chips. Early-season Kennebecs grown under cool weather conditions appear to withstand relatively low transit temperatures (55° F.) for the time normally required for shipment to the mid-west. However, actual transit temperatures early in the season sometimes fall below the safe level. The results of this work are being prepared for publication. (MQ 2-55)

2. Heavy Loads of Maine Potatoes. Preliminary tests conducted with 50-pound paper bags shipped to Boston indicated that there is an increased danger of grade damage occurring to potatoes shipped in very heavy loads, particularly if care is not taken during loading and unloading. This increase in damage could offset savings in freight charges if the damaged potatoes were removed in repacking operations. (MQ 2-42)

#### E. Postharvest disease control

1. Pre-storage Washing. Neither a hot-water dip nor a surface active agent applied at harvest or 1 month after harvest controlled lenticel infection of Maine potatoes. In general, there was more lenticel infection when potatoes were washed at harvest than when washed 1 month after harvest. (MQ 2-93)

2. Hot Water Treatment of Seed Potatoes. Whole seed (B-size) of three varieties were not adversely affected during transit, or in pre-planting storage when treated for 3 minutes at 130° F. and shipped to West Virginia. Emergence date, stand, disease development in the field or weight of sprouts were also not influenced by the hot water treatment. (MQ 2-90)

## PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Objective Measurement of Quality

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Quality Maintenance in Handling and Packaging

Hardenburg, R. E. 1964. Greening of Potatoes During Marketing--A Review. Amer. Potato Jour. 41(7):215-220. (MQ 2)

Quality Maintenance in Storage

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Postharvest Physiology

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## TRANSPORTATION AND MARKETING FACILITIES

### Transportation and Facilities Research Division, ARS

Problem. Returns to producers and prices paid by consumers for horticultural crops are adversely affected by the use of inefficient marketing facilities, equipment, and methods. Better work methods, techniques, devices, operating procedures, equipment, and facility designs are needed for precooling, conditioning, storing, handling, cleaning, washing, waxing, sorting, sizing and packing potatoes, citrus fruits, deciduous fruits, vegetables, and other horticultural crops. Such improvements are needed at both shipping points and terminal markets. They would increase the productivity of labor, prolong the storage life of the commodities, reduce bruises and injuries to these products, reduce marketing costs, expand consumption, and reflect greater returns to producers.

The cost of transporting farm products to market in 1963 was 5 billion dollars. Cost of transporting supplies used in farm production totaled more than one billion dollars. Further, costs of other marketing and production functions, such as loading and unloading vehicles, packaging storage and processing, also are affected by the efficiency of transport. These costs are important to the American farmer because they influence the return he receives from the sale of his products. They also are important to the American consumer because they influence the price he pays for his food. Therefore, the prosperity and efficiency of our entire agricultural industry and the economic well-being of the American consumer are closely tied to the efficiency of our transport system.

In spite of the importance of transport to agriculture and the consuming public, research to make it more efficient and less costly has been meager. New advances in transport and engineering technology, including the development of new materials, new building and operating techniques for transport equipment, containerization and unitization--all offer opportunities to improve agricultural transport. Translating these and other opportunities into working advantage for our agricultural producers and consumers requires a strong program of economic-engineering research. Such a program will help increase returns to American farmers, provide better products and lower costs to American consumers, and improve the competitive position of our farm products in foreign markets.

### USDA AND COOPERATIVE PROGRAM

This is a continuing long-range research program covering the development of improved work methods, techniques, devices, operating procedures, equipment, and facility designs for precooling, conditioning, storing, handling, cleaning, washing, waxing, sorting, sizing and packing potatoes. Potato research is carried on at the Red River Valley Potato Research Center, East Grand Forks, Minn.; the Potato Handling Research Center, Presque Isle, Me.; a field office at Gainesville, Fla., and the Hyattsville, Md., office; in both



laboratory and commercially owned facilities; in cooperation with the North Dakota, Minnesota, Maine, and Florida Agricultural Experiment Stations, the Red River Valley Potato Growers' Association, the Market Quality Research Division, the Agricultural Engineering Research Division, the Marketing Economics Division of ERS, and the Forest Products Laboratory of the Forest Service.

The Federal professional man-years involved were 4.3 for F.Y. 1964.

The economic-engineering research in this field is a long-range program. It seeks to develop improved transport facilities, equipment and techniques and more efficient ways of using them in transporting agricultural products and supplies. It is interdisciplinary in nature, drawing upon the training and experience of economists, mechanical and industrial engineers, marketing specialists and various other scientists. All the work is done with the cooperation of transport firms, transport and refrigeration equipment manufacturers and lessors, trade associations, State universities and experiment stations. Field studies are carried out throughout the U. S. and on overseas shipments. Only one field station, Orlando, Florida, is permanently maintained to support this research program. Part of the work is accomplished through research contracts and cooperative agreements.

At the present time work is underway in each of the following fields:

(1) transport equipment, (2) refrigeration equipment and techniques, (3) better utilization of transport equipment and techniques, (4) loading methods, including unitized loading, (5) development and evaluation of pallet containers, and (6) overseas transport.

The professional man-years involved were 2.5 in F.Y. 1964.

#### PROGRAM OF STATE EXPERIMENT STATIONS

Research concerned with the economics of marketing at the State Agricultural Experiment Stations is reported under the appropriate areas of work of the Multiple Use Report, Marketing Economics Division. Likewise, research dealing with facilities and transportation conducted by the agricultural engineers at the State Experiment Stations is reported in the Multiple Use Report of the Agricultural Engineering Division, Areas 4, 5, and 9. Related research in food science and technology is reported in the Multiple Use Report of the Utilization Research and Development Divisions.

#### PROGRESS -- USDA AND COOPERATIVE PROGRAMS

##### A. Handling and Packing

1. Presque Isle, Me. Research under this project, which is cooperative with the Maine Station, is directed toward reducing operating costs of potato storages and packinghouses by increasing the productivity of labor employed and reducing losses from bruises and mechanical injuries in handling, storing, cleaning, grading, sizing and packing potatoes. It involves the development of more efficient work methods, operating procedures, equipment, and facilities for handling, storing, and preparing for market Maine potatoes.

Experiments on bruise resistance of potatoes, as related to changes in temperature of the surrounding air, were continued. Measurement was made of the amount of bruise injury inflicted by dropping a 0.6 pound weight on individual potatoes from heights of 18, 12, or 9 inches. Tests were made with the potatoes at the storage temperature of 45° F. and after samples were held in 60° F. air for intervals of 1, 2, 3, and 4 hours after removal from storage. The average resistance to bruising had an increasing trend through the warming period with most of the increase occurring in the first two hours. After four hours, the results approximated those of tests on potatoes stored at the 60° F. temperature. Impact from 3 drops of the weight from a height of 12 inches inflicted about one-third as much injury as was produced by two drops from a height of 18 inches. Bruising produced by the impact of four 9-inch drops was almost negligible. Tests made by dropping the weight from progressively increased height until visible bruising occurred, with time and temperature conditions similar to those used in the repeated impact experiment, show generally corroborative results. Results of these tests should provide guides for manufacturers of handling, grading, and packing equipment for producing equipment which will minimize bruising of potatoes.

Additional work was done on a manuscript, "Evaluation of a Bulk Railroad Car for Potatoes," and work was initiated on a manuscript, "Supplying the Packing Line with Potatoes in Maine Storages at Rates Above 200 Hundredweight per Hour."

2. Gainesville, Fla. This program, carried out in cooperation with the Florida Station, has as its objective the development of more efficient work methods, operating procedures, and equipment for the handling and preparation for market of potatoes in spring crop areas.

A draft of a manuscript was prepared based on the results of research conducted in the Hastings-Elkton area to develop improved systems for handling potatoes in bulk from the harvesting operation to the packing line. Drawings and other information from which potato growers and shippers can install a bulk-dumping system, as developed through the research, were included. Preliminary cost estimates for the different systems included in the research showed the bulk-dumping system to be 16 percent lower in cost than the conventional system (hopper-body trucks and sloping-bottom bins) and 19 percent less than for the pallet-box system (boxes filled on truck from harvester).

Two bulk-handling systems were studied in the Homestead area where a commercial installation of each system recently has been made. In a pallet-box system, potatoes are transferred to the boxes after being hauled to the packinghouse in hopper-body trucks. In a drive-in bin system, bin loader equipment is used for receiving potatoes from hopper-body trucks. Information on injury was obtained for each of the two new systems and for a conventional system (digger-field box), following a 6 x 6 latin square statistical design. Data on labor and equipment time requirements for the new systems were obtained through time studies. Tuber injury studies show: (1) There was no

significant difference between the conventional single- or two-row digger used in the conventional system and the mechanical harvester used in the new (bulk) systems; (2) there was no significant difference between receiving in field boxes or receiving in hopper-body trucks directly to the line; and (3) there was no significant difference in holding the potatoes in drive-in bins or in using pallet boxes for holding.

3. Red River Valley Potato Research Center, East Grand Forks, Minn. Work is directed toward developing more efficient work methods, techniques, devices, and equipment for the handling and preparation for market mid-western fall-crop potatoes.

Handling.--A vertical-telescoping, deep-bin filler designed by the Agricultural Engineering Department, University of Minnesota, was tested to evaluate design principles, capacity, and tuber damage. General design seemed quite feasible, but several modifications were found to be needed to reduce tuber injury occurring on the horizontal feeder belt. The vertical conveying section of the machine performed quite satisfactorily.

A scaled down version of the "Spudnik" designed to operate in bulk rail cars was moved from Moscow, Idaho, to the Center but was used only for limited tests because of the serious traction problems which would require extensive modifications of the unit.

Tuber injury evaluations for each machine were made by the Market Quality Research Division.

Cleaning and Sizing Before Storage.--Norland and Pontiac variety potatoes again were sized into storage with the following size classifications: "B" size, less than 2 inches; "A" size, 2 to 3½ inches; "Jumbo" size, over 3½ inches. An expanding-pitch, spool sizer was used. A check bin was filled with field-run potatoes in order to evaluate any effects sizing might have on air movement by comparing temperatures in this bin to temperatures in an identical bin of sized potatoes. Thermocouples and sample bags were placed throughout all bins to measure temperatures and weight loss, volume change and shrinkage respectively.

Generally, for the field-run potatoes over 90 percent were in the "A" size, and less than 5 percent in the "B" and "Jumbo" classes. Samples taken from the "A" section of the sizer contained 92 percent "A's," 5 percent "B's," and 3 percent "Jumbos." Because of the predominance of A-size potatoes in field-run lots, sizing made but little improvement in the field-run lots. Also, because of this small change in the percentages of "A's," bin temperature variations could not be attributed to sizing. Better accuracy in sizing might have been obtained if a more uniform feeding rate could have been maintained.

Weight loss of stored potatoes averaged 4½ percent for 19 samples, and varied from 3½ to 6½ percent. This is consistent with past results for table stock potatoes stored at 32° to 40° F.



Shrinkage or dimensional changes averaged  $2\frac{1}{2}$  percent and ranged from 1.0 percent to  $3\frac{1}{2}$  percent. Generally tubers appeared to shrink an equal amount on each measured axis.

Market Quality Research Division evaluations of the damage done by sizing showed damage to the "A" size tubers was minor, but that "Jumbo" size tubers were more extensively damaged by the sizer.

At Gainesville, Fla., this research has as its objective the development of improved work methods, equipment, devices and operational procedures for the handling and preparation for market of vegetables at shipping points.

## B. Storage

Work under this program, at the Red River Valley Potato Research Center, is directed toward providing optimum storage conditions for fall-crop potatoes for table stock, seed, and processing; and developing improved layouts and designs for potato storage houses, which will permit the use of the most efficient handling and packing methods and keeping injury and mechanical injury to a minimum and minimize construction and maintenance costs.

1. For Table Stock and Seed. Further work was done on rewriting the manuscript, "Fall-Crop Potato Storages." It is intended that this report include recommendations regarding construction techniques, layout and design, air circulation and ventilation systems, insulation, building materials, and other essentials. Preparation of design drawings and specifications for a 60,000 cwt. capacity door per bin storage are about three quarters completed. The initial design was expanded to include shipping room, electrical, and site details. Major portion of time was devoted to structural, ventilation, and electrical design.

Three bin fronts were designed to span the 12-foot bin entrances in the door per bin storage, but have not been tested. A "T" shaped bin front which spans 20 feet was designed and tested. This span is needed to facilitate handling of equipment in wide storage bins.

During the report period, project personnel provided assistance on problems associated with storage construction and regulation, handling, and equipment to over 200 firms and individuals.

2. For Processing. The storage of Irish Cobbler, Pontiac, Kennebec and Snowflake potatoes at  $40^{\circ}$ ,  $45^{\circ}$ , and  $50^{\circ}$  F. and subsequent flaking was continued as in the previous year. Samples were flaked from January through July. The  $40^{\circ}$  and  $45^{\circ}$  F. samples were reconditioned for 4 weeks at  $65^{\circ}$  F. Results to date show that storage temperatures did not affect any of the recorded flake variables.



Storage temperature, relative humidity and potato weight loss data have not been completely analyzed. Temperature control in the controlled temperature rooms was more precise this year throughout the whole storage period. Relative humidity control above 80 percent needs to be improved.

The effect of shell ventilation and a combination of shell and through ventilation methods on storage temperature uniformity was evaluated for chip stock storage at an average temperature of 55° F. Actual airflow rates were approximately .35 c.f.m. per hundredweight, which is half the flow used by most commercial operators. This reduced rate was used because of air distribution problems. Temperature data are still being analyzed. All lots of potatoes chipped satisfactorily.

Weight loss at 55° F. average temperature varied from 4 to 9 percent and averaged 6 percent. There was no definite relationship between ventilation methods and weight loss at the airflow rates used.

#### C. Handling and Packing Fruits and Vegetables on Terminal Markets

1. Tiering Devices and Equipment. This research by the Hyattsville office was directed toward reducing the cost of storing fruits and vegetables at the wholesale level by increasing the utilization of available storage space in wholesale fruit and vegetable warehouses. During the report year work in this area was confined to the editing and publication of Marketing Research Report No. 622, "Storing Fruits and Vegetables on Pallets in Wholesale Warehouses."

2. Loading Out Delivery Trucks. The purpose of this research was to evaluate and compare the relative efficiency of selected methods and types of materials handling equipment for order assembly and truckloading used by wholesale distributors of fresh fruits and vegetables supplying both affiliated and non-affiliated retail stores so as to reduce unit costs and minimize spoilage and waste. The research was cooperative with the Wholesaling and Retailing Research Branch. During the report period work in this area was confined to the editing and publication of Marketing Research Report No. 665, "Three Methods for Loading Out Produce in Warehouses."

#### D. Transport Equipment

1. Thermal Rating of Refrigerated Trucks. This research is being conducted in cooperation with the National Bureau of Standards at the NBS facility in Washington, D. C. Its purpose is to develop a standard rating method to measure the thermal efficiency of refrigerated delivery truck bodies under conditions of 100° F. ambient, 50 percent ambient humidity, and 0° F. interior temperature.

Work was continued on the measurement of the rates of air exchange and the effect on load cooling caused by opening the door of a refrigerated truck. Preliminary tests were made using thermocouples, heat flow meters, and rapid response air flow probes designed and constructed at NBS. These instruments are used in conjunction with metered liquid nitrogen to maintain the steady-state interior temperature prior to the door opening and to restore the temperature immediately after the door is closed. Nitrogen from a self-pressurizing Dewar container is admitted to the interior through solenoid valves controlled by an air temperature multiple thermocouple grid. The heat load caused by the door opening can be determined by measuring the nitrogen required in excess of that required to maintain the steady-state temperature difference.

It is now anticipated that a final report will be issued during the next year.

2. Air Circulation in Refrigerated Trailers. The purpose of this research is to determine the most practical system for circulating cold air to obtain uniform temperature throughout a trailer load of frozen food. Previous tests have shown that temperatures at the front of a trailer near the cooling coils can be at 0° F. while other locations in the load may be several degrees above zero. This study seeks to find the best combination of blowers, air ducts, floor racks, and wall spacers to eliminate areas of high temperature. This is a cooperative program with the National Bureau of Standards being conducted at the NBS facility in Washington, D. C.

Work during the reporting period was devoted to analysis and reduction of the large amount of data obtained from previous trailer tests. Preliminary analysis of the tests comparing continuous and cyclic blower operation indicated somewhat greater load temperature changes during refrigeration "off" periods under the 12° F. thermostat differential, compared to 4° F. and 6° F. when the blower was operated continuously. The thermostat sensing element was located in the return air stream near the evaporator coils and behind a bulkhead near the front of the trailer. The space forward of the bulkhead warmed faster than the cargo space when the blower was cycled off. With the blower under constant operation under the refrigeration "off" cycle, the forward space warmed more slowly, at approximately the same rate as the cargo space.

The 12° F. thermostat differential produced exposed cargo surface temperature changes of about 10° F. when the blower was cycled and about 8° F. when the blower operated continuously. Center cargo temperatures changed about 0.5° F. in each case. All tests were conducted with ambient temperatures of 100° F. and mean interior (return air) temperature of 0° F.

3. Liquid Nitrogen Refrigeration for Frozen Food Trailers. The objective of this study is to determine whether it is practical to use liquid nitrogen as a refrigerant in vehicles transporting frozen foods. Previous research has shown that liquid nitrogen and liquid carbon dioxide will provide 0° F. temperature for frozen foods. However, analysis shows that these expendable refrigerants are more costly than conventional mechanical systems. This project is being discontinued until costs of expendable refrigerants are reduced sufficiently to make their use economically feasible.

4. Multi-Purpose Transport Vehicles. Van Containers--A design concept for a multi-purpose van container was developed during the year. It was described in a press release which generated widespread interest among steamship lines, railroads, freight forwarders, trucking groups, transport and refrigeration equipment manufacturers. Meetings were held with representatives of these groups and several offered to make available their facilities and technical assistance in engineering, construction and testing of the prototype van. An application for public-use patent on the van is now being processed.

The container can be used to haul both frozen and nonfrozen perishable products and nonrefrigerated cargo. It also can be used to carry freight by rail piggyback, highway, water (fishyback), and perhaps by air in moving farm products to the consumers.

Trailers--Research was begun late in the year to develop practical, low cost, conversion systems by which conventional refrigerated trailers and dry cargo vans can be made dual-purpose vehicles for use in transporting bulk as well as packaged cargo. It is being carried out under a cooperative agreement with the Oregon Agricultural Experiment Station. Several trailers equipped with prototype conversion systems are now being tested in cooperation with several trucking firms in the Pacific Northwest. Initial results indicate that the rates of vehicle utilization are materially increased when the conversion systems are used. However, the project has not progressed far enough to obtain adequate data on vehicle utilization rates, operating costs, and revenue yields.

5. Improved Ventilated Piggyback Trailers. Research to develop improvements in rail piggyback trailers which will facilitate better product ventilation was continued during the year. Previous work showed that conventional highway trailers used for this service did not provide a flow of outside air through loads of perishables sufficient for adequate cooling.

Several trailers incorporating new ventilation systems were tested with shipments of watermelons from Florida to northern markets. One type van tested was equipped with adjustable scoops on the front ventilation doors to direct air into the van when hauled rear-end-forward on rail piggyback flat cars. Another type studied had under-floor scoops to direct air into the cargo area where the ram-effect forced it upward through the load and



out the exhaust ports in the upper sidewalls of the van. The latter type trailer gave the best results. In paired tests the temperature of watermelons in a conventional van rose three degrees during transport while those shipped in the van with under-the-floor air scoops cooled 15 degrees. Additional work to develop further refinements in this system and to develop and test new equipment is being continued.

## E. Transport Techniques

1. Pallet Containers for Transportation. All field work has been completed, the data analyzed and results evaluated on rail and truck shipments of apples in both expendable and reusable pallet containers of several different types. The initial report was extensively revised during the year. It is now being reviewed.

This research has shown that savings from using pallet containers of about 900 pounds capacity as compared to conventional 40 pound corrugated boxes range from 0.1 cents per pound, or about \$150.00 per carload for one trip to 0.2 cents, or approximately \$300.00 per car when the pallet containers are used for two trips. For some types of pallet containers greater savings may be made by using them for three or more trips. The economies in pallet container usage in transport result from lower container, packing, handling, freight and protective service costs per pound of fruit.

2. Loading Methods for Potatoes. Five air-flow loading patterns were developed to improve air circulation in motortruck shipments of bagged potatoes by providing a number of continuous longitudinal channels through the load. Tests results showed that when the trucks operated at approximately 50 miles per hour under ventilation, the average velocity of air movement in the circulation channels ranged from 141 feet per minute to 274 feet per minute and the range over the top of the load was from 280 fpm to 472 fpm. Air movement through the channels caused temperatures throughout the load to change directly with the outside air temperature. The air moving through the channels also made it possible in some instances to remove excess moisture from damp potatoes. The new patterns are easy to load in any size vehicle and provide the trucker a full payload with proper weight distribution. The patterns are stable and remain intact during transit and do not increase container or product damage.

The report on this research has been submitted for publication. This project has been discontinued.

3. Unitized and Palletized Transport. A literature review of systems analysis and operations research applications to the handling and transporting of agricultural commodities was completed during the year. This information has been used to plan work in which this research technique will be used to evaluate different methods of unitized and palletized transport.



Observations were made of the operations of handlers and shippers of carrots in California, Arizona, and Texas to determine the feasibility of applying systems analysis and operations research techniques to improve transport and handling of this product. Data developed in this survey have been used to construct a "word model." This model may serve as the basis for constructing a mathematical model which can be used to predict the results of changes in any part of the transport system for a particular product.

#### PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

##### Handling and Packing Potatoes

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Guilfooy, R. F., 1964. Transport of Perishable Foods. Paper presented at the Annual Food Engineering Conference, Michigan State University. April 1964.

### Transport Techniques

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## COOPERATIVE MARKETING

### Marketing Division, FCS

Problem: Farmers are expanding their use of cooperative marketing. There are constant changes in transportation, processing, and distribution technology, and in market organization and practices, and changes on the farm itself. In view of these developments, farmer cooperatives and other marketing firms require research results to perform both efficiently and effectively. Such research can assist farmers to maintain and strengthen their bargaining power, increase efficiency, and meet the quality, quantity, and service needs of today's food and fiber marketplace.

Cooperative marketing is a major way for farmers to get maximum returns from their products in the current and rapidly changing market. Farmers own and control cooperatives specifically to increase their income from crops and livestock. Gains are not automatic, however. Cooperatives must plan, develop, and actually manage the specific marketing program and services that will yield the most for their members. Marketing cooperatives must know what the market demands. They must be able to compute the probable cost of different ways of serving the market. They must understand the possibility of major economies in a well coordinated joint sales program, and understand the methods and potentials of bargaining. Management must achieve minimum costs through improved organization, good use of existing plant and personnel, and the selection and use of new equipment and methods.

### USDA AND COOPERATIVE PROGRAM

The Department conducts a continuing long-range program of basic and applied research and technical assistance on problems of marketing farm products cooperatively. Studies are made on the organization, operation, and role of farmer cooperatives in marketing. While most of the research is done directly with cooperatives, the results are generally of benefit to other marketing firms. The work is centered in Washington, D.C. Many of the studies, however, are done in cooperation with various State experiment stations, extension services, and departments of agriculture.

Federal professional man-years devoted to research in this area totaled 23.3, of which 1.0 was devoted to work on potatoes.

Research also is conducted under contract with land-grant colleges, universities, cooperatives, and private research organizations. During the period of this report, contract research was performed by universities and colleges in Florida, Iowa, Louisiana, Montana, North Dakota, and West Virginia, and by one private research company.

## PROGRAM OF STATE EXPERIMENT STATIONS

The State stations maintain a very broad research program in commodity marketing, the findings of which are valuable to cooperatives and to other marketing firms. There are at this time nine projects in eight States that deal specifically with cooperative marketing. Five projects are commodity oriented and deal with grain, tobacco, milk, livestock, and fruits and vegetables. These projects seek to find out how cooperatives are adjusting or might better adjust to changes in market structure and marketing practices. In some instances researchers are studying the success and failure of cooperatives and the organizational structure. One study of the history of major cooperative marketing associations in the State will be published as a book and will undoubtedly receive nationwide attention.

Because of the growing interest in the role of cooperatives in market structure, one State recently initiated a major project in this area. The project leader views cooperative enterprises as a structural dimension of farm markets. The objectives and operating procedures of cooperatives will be studied to see if they have a unique impact upon market conduct and performance. If so, this may have significant implications for Government policies and programs.

The total research effort on cooperative marketing in the eight States is 3.4 professional man-years.

### PROGRESS -- USDA AND COOPERATIVE PROGRAMS

#### Improving Cooperative Sales and Distribution Methods

Marketing problems of the Maine potato industry were studied and suggestions made about the feasibility of bargaining activity. Procedures necessary to initiate bargaining were outlined. Findings stressed the importance of obtaining full grower support before bargaining is initiated.

A study was completed of shipping point practices and product preferences of important wholesale buyers of Virginia white potatoes. It was found: (1) The preferences of chainstore, chipper, and itinerant buyers vary with respect to potato characteristics, container sizes and types, and shipping point services desired; (2) A high proportion of buyers get most of their potatoes directly from growers or shippers in the production area. Individual Virginia growers find it difficult to satisfactorily meet quantity and quality requirements of large-scale buyers. However, buyers think the Virginia industry is equal to other areas in practices and services provided at shipping point; (3) Virginia growers and shippers may improve their industry position by practicing more strict grading and sizing of product, and by initiating more orderly marketing. This study was done jointly with the Virginia State Department of Agriculture.



## PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

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ECONOMICS OF MARKETING  
Marketing Economics Division, ERS

Problem. Most agricultural processing industries are experiencing rapid and drastic changes in their market organization and practices. These changes are affecting both farmers and consumers. Research is needed to keep abreast of such changes and to indicate their probable consequences. There have been substantial advances in recent years in increasing efficiency and reducing costs through adoption of new technology in producing, assembling, processing, and distributing farm products. However, for producers and marketing firms to remain competitive additional information is needed on margins, costs, economics of scale and efficiencies possible in the marketing of farm products.

Marketing research also is increasingly concerned with evaluating present and prospective programs pertaining to agriculture, such as the Food Stamp Program and Federal Grading Activities and to the changing structure of market industries as this may influence the bargaining power of farmers. Research also is being directed to the economics of transportation and storage activities of both private firms and government. Increasing attention is being given to the longer-term outlook for various products and markets as an aid in better assessing the prospects for increasing industrial employment under the Rural Development Program and in assessing prospective interregional shifts in the areas of production and marketing for specific products.

USDA AND COOPERATIVE PROGRAM

The Department conducts a continuing program involving a series of studies to show: (1) Detailed analyses of marketing costs and margins in the various stages and channels in handling, processing, transporting, and distributing horticultural and special crops and related products; (2) comparative efficiency and costs of present agencies, organizations, methods, and practices in performing the services involved at each important stage in taking the crop products from farms to final users; and (3) the influences on costs and efficiency of such factors as grades and standards, methods of determining and maintaining product quality, and governmental regulatory and informational programs. On the basis of results of such studies, recommendations are made on possible means of increasing the efficiency of marketing, or increasing returns to growers, and of providing consumers with the choices they desire.

The Federal scientific effort devoted to this research in F.Y. 1964 amounted to 2.5 professional man-years.

## PROGRAM OF STATE EXPERIMENT STATIONS

Potatoes. Research at the State agricultural experiment stations is centered largely in Maine, Idaho, and the Red River Valley. Much of it relates to trends in market structure and practices, the extent to which producer and wholesaler practices meet the needs of large-scale buying by retailers, development of suggested organizational structure which will increase marketing efficiency as well as increase returns to growers, and the trends in utilization patterns as between fresh and processed. The largest segment of research relates to costs of assembly, grading, and packaging.

A total of 5.8 professional man-years.

## PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Structure, Practices and Competition

1. Data for a study of the structure of the Red River potato market are being analyzed. Inspection data have been obtained from the Red River Valley Growers Association and from 105 marketing firms. Building and machinery costs have been developed for 5 plants with different packing and storage capacities. The analyses will continue in F.Y. 1965 and projections will be made of number and sizes of firms needed in the future to handle potatoes grown in the Red River Valley.
2. A study of market orders for fruits, vegetables and potatoes has indicated that quality regulations under potato marketing order programs have enabled producers to increase their returns. An analysis of prices received by market order and non-market order areas before and after the adoption of the programs indicate that prices received by producers in market order areas have generally increased relative to prices received by growers in the non-market order areas. This price increase occurred in spite of large production increases in market order areas and a general production decline in non-market order areas. During F.Y. 1965 further analyses will be made of potato marketing orders and the affects of a rapidly growing processing industry on the effectiveness of potato market orders.

B. Margins, Costs and Efficiency

A continuing study of marketing margins for fruits and vegetables disclosed that, in 1957-62, the average cost of marketing 4 varieties of potatoes in selected retail markets was 70 percent of their retail prices in each of the markets. The retail margin averaged 45 percent of the retail price; marketing agencies between the shipping point and the retail store received 25 percent of the retail price. Potato growers and packers received 30 percent. Retail price spreads for specific varieties ranged from 44 percent of the retail price for Western Long Whites to 53 percent for Eastern Round Whites. Tabulations of price spreads at the various levels of the marketing channels will continue during FY 1965, with continued efforts to improve the measurement statistics.

### C. Market Potentials

1. Market Acceptance of Explosion Puff Dehydrated Products. Exploratory research has been initiated on the application of the explosive puff dehydration process on blueberries, a development of EU, for pie baking. These berries rehydrate much more quickly than conventionally dried materials. Preliminary testing of the dehydrated blueberries in pie baking operations showed the flavor of the product was satisfactory. Problems revealed in use of the berries in testing such as level and type of starch used can easily be overcome.

Further research is planned to obtain additional information on institutional market outlets which appear promising in terms of volume and types of products now used and the influence of the explosion puff dehydrated product on the overall costs and efficiency of institutional operations. It is anticipated that the experience gained in the work on blueberries will be applied to other explosive puffed products, such as apple slices and potato pieces.

2. Potentials for Freeze-Drying. A new marketing technology of interest to food processors, food handlers, producers, and consumers is freeze-drying. An economic evaluation of the industry shows that over 50 products are now on the market with most of them going to secondary processing and institutions. Retail markets appear limited. At present, 12 firms in the United States and about 20 companies abroad process freeze-dried foods. A projection of freeze-drying shows that in the future, with economies of size that are probable for the industry, costs may be as low as 5 cents per pound of water removed. This compares with spray and roller drying costs of less than 1 cent. A projection of volumes shows that we may expect 42 plants to be in operation by 1970, and by that time volumes would have increased from the present 11 million pounds in 1963 to 250 million.

### D. Transportation Costs and Services

1. Transportation of Fresh Fruits and Vegetables. This is a two-phase project dealing with interstate rail and highway transportation of California and Arizona fruits and vegetables and is concerned with the flow patterns and trends associated with rail and highway movement of fresh produce from California and Arizona to other States.

Striking changes have taken place in the use of highway and rail carrier service. Since 1951, the share of interstate traffic dispatched from California and Arizona shipping points by rail has dropped from 87 to 70 percent of total movement from those areas. The decrease has occurred primarily because shipments moving to points west of the Mississippi River --short and intermediate range hauls--have been tending to go more and more by truck. Trucks have increased their share of shorthaul traffic from 67 to 83 percent of the total and their proportion of intermediate range hauls from 20 to 66 percent. These shifts in shippers utilization of carriers



reflect the motor carrier's ability to offer attractive rates and fast service. In many instances motortruck transportation has become so much more attractive than rail service that some users are willing to pay higher charges for truck service than they would have needed to pay for the nearest comparable rail service.

The second phase of this study, based on receiver interviews, is scheduled for completion by December 1964. Preliminary findings confirm those of the shipper survey. Receivers utilize rail and truck service to improve plant operations and to serve customers better.

2. Fresh Potatoes. A preliminary survey of fresh potato transportation was made during the year. Shipments from the major production areas to markets have been affected markedly by many factors, including transportation. Together all forces have caused Idaho to become the nation's largest potato producer and Maine the second largest. These two States changed positions in 1957 despite the fact that Maine is much closer to a larger portion of the nation's population than Idaho. Very favorable rail freight rates have helped Idaho. Truck transportation, which is usually used for short and intermediate range hauls, is more costly than rail except where truckers are able to haul potatoes as a "filler" payload on an otherwise empty segment of a round trip circuit.

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## ECONOMIC AND STATISTICAL ANALYSIS

### Economic and Statistical Analysis Division, ERS

Problem. Because of the instability of the prices he receives and rapidly changing conditions of agricultural production, the farmer stands in special need of accurate appraisals of his economic prospects if he is to plan and carry out his production and marketing activities in an efficient and profitable way. The typical farmer cannot afford to collect and analyze all the statistical and economic information necessary for sound production and marketing decisions. It has long been a goal of the Department to provide the farmer with economic facts and interpretations comparable to those available to business and industry, through a continuous flow of current outlook information; the development of longer range projections of the economic prospects for the principal agricultural commodities; and analyses of the economic implications of existing and proposed programs affecting the principal farm commodities.

Producers, processors, distributors and consumers need better information on the supplies, production and consumption of farm products, and the effect of these and other factors on the prices of these products. Similarly, Congress and the administrators of farm programs need to evaluate alternative proposals to modify existing price support and production control programs in terms of their impact on production, consumption and prices received by farmers.

### USDA AND COOPERATIVE PROGRAM

#### Commodity Situation and Outlook Analysis

This work involves 0.5 professional man-years in Washington. The outlook and situation program provides a continuing appraisal of the current and prospective economic situation of fresh and processed vegetables and potatoes. Results of these appraisals, and findings of special studies are published in quarterly issues of the Vegetable Situation, the National Food Situation, the Demand and Price Situation, and monthly in the Farm Index. A comprehensive analysis of the vegetable and potato situation is presented at the Annual Outlook Conference. Appraisals also are presented at regional or State outlook meetings, and at meetings of farm organizations and various agricultural industry groups. Special studies are made to determine probable effect of proposed programs on supply, price and consumption of vegetables. Basic statistical series are compiled, improved, and maintained for use in statistical and economic analysis.

## Supply, Demand, and Price

This work involves 0.5 professional man-year located in Washington, D. C., making separate analyses for the total U. S. crop, the various seasonal crops, and the major producing areas. The analyses measure the effect of price and other factors on acreage and production of potatoes; the effect of supplies and other factors on price and utilization of potatoes; the effect of price, income, and other factors on consumption; and the effect of price and other factors on storage demand and level of storage.

### PROGRAM OF STATE EXPERIMENT STATIONS

For the most part the States depend upon the U.S. Department of Agriculture for the yearly across-the-board commodity situation and outlook research. The State extension staff members supplement and adapt such research information to meet the commodity situation of their States.

Four States have projects that deal specifically with analysis of current price trends and prediction of future prices. There is increasing interest in longer range price prediction because of the growing specialization of farms, which make yearly enterprise shifts less common and less feasible, and which calls for large capital commitments over longer periods of time.

The total direct research effort in the situation and outlook area is approximately 1.7 professional man-years. While not designated as outlook research, much of the research conducted by the experiment stations and reported elsewhere contributes to improved understanding of price-making forces, which in turn improves market situation analysis and price forecasting. Figures on manpower on potatoes are not available.

The States are engaged in research on price analysis, demand functions for a large number of commodities, supply response to price changes, the determination of changes taking place in the seasonal price pattern, the effect of quality differences on price, market prospects for new products, and on price relationships abroad. The total State research effort in this area is approximately 53 professional man-years, of which 4.0 is on fruits and vegetables. Manpower on potatoes is not available.

### PROGRESS -- USDA AND COOPERATIVE PROGRAMS

#### Commodity Situation and Outlook Analysis

A study of consumption patterns for potatoes indicated that the per capita use of fresh potatoes has continued to decline during the past decade. But rising popularity of such processed potato products as chips, frozen French fries, and potato flakes appears to have halted the long-term downward trend in overall potato consumption. More than a fourth of the total volume of potatoes now used for food is processed. Through 1968, potato use per person may approximate that of recent years. Because of larger population,



however, total requirements for potatoes for food are likely to show a moderate increase. At the same time, processed items are likely to account for an increasing share of the expanding total potato food market.

During the past year the commodity specialist continued to serve as Economic Advisor to the National Potato Advisory Committee. Efforts were devoted to appraisals of the influence of present and proposed programs on potato production, prices, and income. Several basic statistical series were revised to include data for Alaska and Hawaii back to 1960.

#### B. Supply, Demand and Price

Substantial progress has been made in preparation of a bulletin on price, supply, and demand for potatoes. Several demand analyses were revised. In addition, a special study was prepared to determine the probable effect of a proposed acreage allotment program on supply and price of fall (storage) potatoes and early season potatoes. It was assumed that a program would be operational for storage potatoes but not for winter and early spring potatoes. A paper was prepared on competitive behavior and substitutability between early season potatoes and storage potatoes. Results indicated that consumers readily substituted one type of potato for the other, but they have preferences for certain types of potatoes and are willing to pay more for their choice.

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